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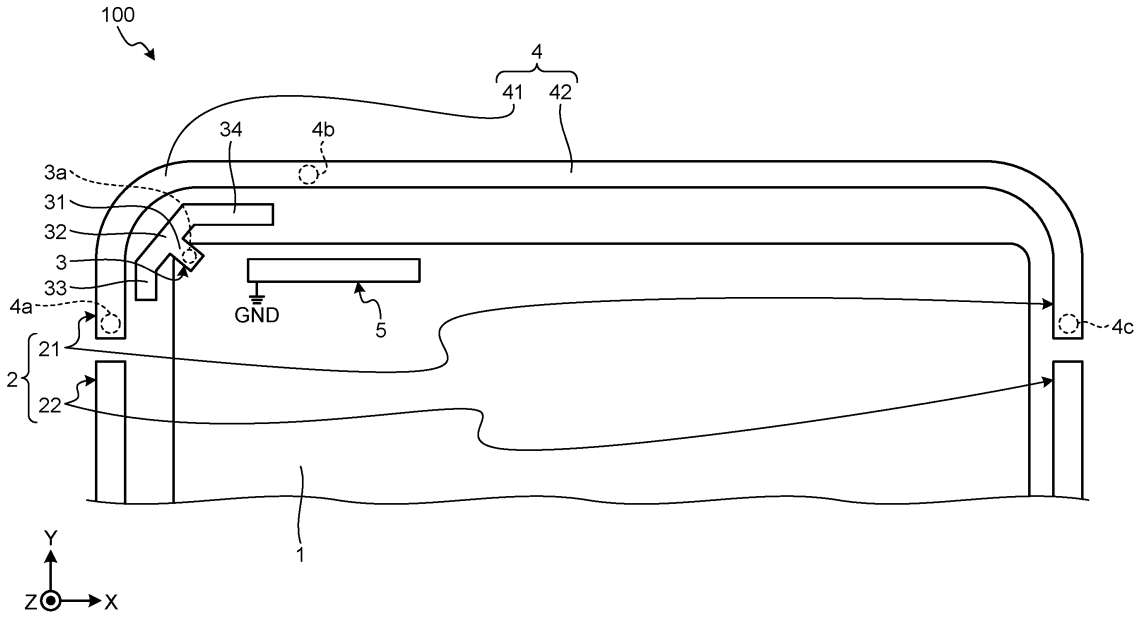
(54) **ANTENNA DEVICE, AND COMMUNICATION DEVICE**

(57) An antenna device includes a feed antenna element, and a housing that includes a parasitic antenna element extending to be electrically coupled to the feed antenna element and having a resonance frequency different from that of the feed antenna element.

FIG.1



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Description

Field

[0001] The present disclosure relates to an antenna device and a communication apparatus.

Background

[0002] For example, Patent Literature 1 discloses a method to make a housing have the same resonance frequency as that of a feed antenna element, in order to reduce an influence of the housing on a radiation characteristic of the feed antenna element.

Citation List

Patent Literature

[0003] Patent Literature 1: WO 2016/125556 A

Summary

Technical Problem

[0004] It is considered that the resonance frequency of the housing may be used for supporting multiple bands. However, Patent Literature 1 has not studied this point at all.

[0005] One aspect of the present disclosure provides an antenna device and a communication apparatus that are configured to support multiple bands.

Solution to Problem

[0006] An antenna device according to one aspect of the present disclosure includes: a feed antenna element; and a housing that includes a parasitic antenna element extending to be electrically coupled to the feed antenna element and having a resonance frequency different from that of the feed antenna element.

[0007] A communication apparatus according to one aspect of the present disclosure includes: a feed antenna element; and a housing that includes a parasitic antenna element extending to be electrically coupled to the feed antenna element and having a resonance frequency different from that of the feed antenna element, wherein communication is performed by using the feed antenna element.

Brief Description of Drawings

[0008]

FIG. 1 is a diagram illustrating an exemplary schematic configuration of an antenna device according to an embodiment.
FIG. 2 is a diagram illustrating an exemplary schematic configuration of connection units.
FIG. 3 is a table illustrating an example of a plurality of resonance frequencies.

Description of Embodiments

[0009] The embodiments of the present disclosure will be described in detail below with reference to the drawings. Note that in the following embodiments, the same elements are denoted by the same reference numerals and symbols, and redundant description thereof will be omitted.

[0010] Furthermore, the present disclosure will be described in the order of items shown below.

1. Embodiments

2. Effects

1. Embodiments

[0011] FIG. 1 is a diagram illustrating an exemplary schematic configuration of an antenna device according to an embodiment. FIG. 1 is also a diagram illustrating a schematic configuration of part of a communication apparatus in which the antenna device is incorporated. An example of the communication apparatus includes a mobile communication apparatus such as a smartphone. The communication apparatus performs communication by using the antenna device 100, more specifically, a feed antenna element 3 and the like which will be described later.

[0012] The antenna device 100 includes a substrate 1, a housing 2, the feed antenna element 3, a parasitic antenna element 4, and an additional parasitic antenna element 5. As will be described later, the parasitic antenna element 4 is included in the housing 2. For convenience of description, an XYZ coordinate system is illustrated. An X-axis direction and a Y-axis direction correspond to a plane direction of the substrate 1. A Z-axis direction corresponds to a thickness direction of the substrate 1.

[0013] The substrate 1 has a ground having a reference potential (hereinafter, referred to as "ground GND"). The substrate 1 is provided with various other elements in addition to the illustrated elements. Examples of the other elements include a circuit that generates a transmission signal of the feed antenna element 3, a circuit that performs processing or the like of a reception signal, and the like.

[0014] The housing 2 houses the substrate 1, the feed antenna element 3, and the additional parasitic antenna element 5. The other elements which are not illustrated (e.g., a battery of the communication apparatus) can also be housed in the housing 2. The housing 2 includes a housing 21 and a housing 22. The housing 21 and the housing 22 constitute, on an XY plane, a frame body (frame portion) surrounding the substrate 1, the feed an-

tenna element 3, and the additional parasitic antenna element 5.

[0015] The housing 21 constitutes an upper portion (a portion in a positive Y-axis direction) of the frame body. The housing 21 constitutes an upper side portion and corner portions on both sides of the frame body. The housing 22 constitutes at least part of a portion below the housing 21 (portion in a negative Y-axis direction).

[0016] The housing 21 and the housing 22 have conductivity. An example of the material thereof is metal. The housing 21 and the housing 22 are separated from each other in the housing 2. In this example, a gap is provided between the housing 21 and the housing 22. The portion of the gap may be filled with an insulator such as resin. An upper end portion (a portion opposed to the housing 21) of the housing 22 may be connected to the ground GND.

[0017] The housing 21 also has a certain length in the Z-axis direction so as to have an inner side surface facing the feed antenna element 3 and the like.

[0018] The feed antenna element 3 has a resonance frequency. The resonance frequency of the feed antenna element 3 is a frequency in a frequency band used for the antenna device 100. An example of the frequency band used is a communication frequency band for the communication apparatus. Examples of the communication frequency band include a band of 700 MHz to 960 MHz, a band of 1400 MHz to 1510 MHz, a band of 1710 MHz to 2200 MHz, a band of 2300 MHz to 2700 MHz, a band of 3400 MHz to 3600 MHz, a band of 3600 MHz to 4100 MHz, and a band of 4500 MHz to 4600 MHz.

[0019] Examples of the feed antenna element 3 include a laser direct structuring (LDS) antenna, a metal pattern formed on the substrate 1, and the like. In this example, the feed antenna element 3 is provided near a corner on the left side (in a negative X-axis direction) of the housing 22. However, the position of the feed antenna element 3 is not limited to that in the example illustrated in FIG. 1.

[0020] The illustrated feed antenna element 3 includes a base portion 31, an extending portion 32, an extending portion 33, and an extending portion 34. The base portion 31 extends from one end portion having a feed point 3a toward the corner of the housing 22, in an upper left direction (direction between the negative X-axis direction and the positive Y-axis direction). However, the shape of the feed antenna element 3 is not limited to that in the example illustrated in FIG. 1. The feed antenna element 3 may have various shapes such as an L-shape, in addition to the substantially T-shape as illustrated in FIG. 1.

[0021] The extending portion 32 extends from an end portion of the base portion 31 to both sides. The extending portion 33 is connected to one end portion of the extending portion 32 and extends in a direction different from an extending direction of the extending portion 32. The extending portion 34 is connected to the other end portion of the extending portion 32 and extends in a direction different from the extending direction of the extending portion 32. The extending portion 32, the extending portion 33, and the extending portion 34 almost extend along the corner portion of the housing 21. In this example, the extending portion 32 extends facing the corner of the housing 21. The extending portion 33 extends downward (negative Y-axis direction), along a left side portion (portion in the negative X-axis direction) of the housing 21. The extending portion 34 extends rightward (positive X-axis direction) along the upper side portion of the housing 21. Note that at least some of the extending portion 32, the extending portion 33, and the extending portion 34 may be smoothly curved, for example, along the corner of the housing 21.

[0022] The extending portion 32, the extending portion 33, and the extending portion 34 have a certain length in the Z-axis direction as well so as to have a surface facing the inner side surface of the housing 21 which has been described above. Specifically, the extending portion 32 has a surface facing the inner side surface of the corner portion of the housing 21. The extending portion 33 has a surface (surface extending in a YZ plane direction) facing the inner side surface of the left side portion of the housing 21. The extending portion 34 has a surface (surface extending in an XZ plane direction) facing the inner side surface of the upper side portion of the housing 21.

[0023] The feed antenna element 3 has a resonance frequency according to an electrical length of the feed antenna element 3. The electrical length of the feed antenna element 3 is mainly given by the extending portion 32, the extending portion 33, and the extending portion 34. The resonance frequency of the feed antenna element 3 is a frequency at which the electrical length from a feed point F to an end of the extending portion 33 or an end of the extending portion 34 is $\lambda/4$ (λ is a wavelength).

[0024] The parasitic antenna element 4 is included in the housing 2 (is part of the housing 2). In this example, the parasitic antenna element 4 is the housing 21. The parasitic antenna element 4 extends so as to be electrically coupled to the feed antenna element 3 in the frequency band used for the antenna device 100. The electrical connection between the feed antenna element 3 and the parasitic antenna element 4 includes capacitive coupling.

[0025] The parasitic antenna element 4 has a resonance frequency according to an electrical length of each portion (first portion 41 and a second portion 42 which will be described later) of the parasitic antenna element 4. Similarly to the resonance frequency of the feed antenna element 3, the resonance frequency of the parasitic antenna element 4 is also a frequency in the frequency band used for the antenna device 100. The resonance frequency of the parasitic antenna element 4 is different from the resonance frequency of the feed antenna element 3. The resonance frequency of the parasitic antenna element 4 may be a frequency included in a band different from the band including the resonance frequency of the feed antenna element 3. The parasitic antenna element 4 may have a plurality of resonance frequencies

included in different bands.

[0026] The resonance frequency of the parasitic antenna element 4 may be lower than the resonance frequency of the feed antenna element 3. When the resonance frequency of the parasitic antenna element 4 is lower than the resonance frequency of the feed antenna element 3, the feed antenna element 3 is reduced in size relative to the parasitic antenna element 4. Therefore, the feed antenna element 3 can be structurally included in the parasitic antenna element 4, contributing to reduction in size. In addition, the feed antenna element 3 is allowed to be coupled to the parasitic antenna element 4, as a transmission path, without interfering with radiation of the feed antenna element 3 alone.

[0027] The parasitic antenna element 4 includes the first portion 41 and the second portion 42. In this example, the first portion 41 is a portion positioned on the left side (in the negative X-axis direction), and the second portion 42 is a portion positioned on the right side (in the positive X-axis direction). The first portion 41 has a length (boundary with the second portion 42) is determined by the position of a contact 4b which is described later. The first portion 41 is a portion on the left side including the contact 4b, and the second portion 42 is a portion on the right side from the contact 4b.

[0028] The first portion 41 corresponds to the corner portion on the left side of the housing 21. The first portion 41 extends along the extending direction of the feed antenna element 3 so as to generate the capacitive coupling with the feed antenna element 3 (constitution of a transmission line). The housing 21 faces the extending portion 32, the extending portion 33, and the extending portion 34 of the feed antenna element 3, at the corner portion, which causes the capacitive coupling between the first portion 41 and the feed antenna element 3.

[0029] The length of the first portion 41 is preferably longer than the length of the feed antenna element 3. Therefore, electrical coupling between the first portion 41 of the parasitic antenna element 4 and the feed antenna element 3 can be enhanced. Specifically, the resonance frequency of the parasitic antenna element 4 lower than the resonance frequency of the feed antenna element 3 makes it possible to couple the feed antenna element 3, as the transmission path, to the parasitic antenna element 4 without interfering with the radiation of the feed antenna element 3 alone.

[0030] The second portion 42 contiguously extends from the first portion 41. The second portion 42 is electrically coupled to the feed antenna element 3 via the first portion 41.

[0031] The parasitic antenna element 4 includes a contact 4a, the contact 4b, and a contact 4c that are connectable to the ground GND.

[0032] The contact 4a and the contact 4b are provided in the first portion 41. The contact 4a is provided at one end portion of the first portion 41 (end portion on a side opposite to the second portion 42). The contact 4b is provided at the other end portion of the first portion 41 (end portion on a side to the second portion 42). In other words, the contact 4b determines the position of the other end portion of the first portion 41 (boundary between the first portion 41 and the second portion 42) in the parasitic antenna element 4.

[0033] The contact 4c is provided in the second portion 42. The contact 4c is provided at the other end portion of the second portion 42 (end portion on a side opposite to the first portion 41). Note that one end portion of the second portion 42 (end portion on a side to the first portion 41) is connected to the other end portion of the first portion 41.

[0034] The antenna device 100 also includes connection units that are configured to connect the contact 4a, the contact 4b, and the contact 4c to the ground GND. This configuration makes it possible to ensure the ground of the parasitic antenna element 4 so that the parasitic antenna element 4 can have the resonance frequency. The connection units will be described with reference to FIG. 2.

[0035] FIG. 2 is a diagram illustrating an exemplary schematic configuration of the connection units. Three connection units of a connection unit 6a, a connection unit 6b, and a connection unit 6c are illustrated.

[0036] The connection unit 6a is a first connection unit that is provided between the contact 4a and the ground GND. The connection unit 6a includes a contact portion 61a and a connection circuit 62a.

[0037] The contact portion 61a brings the contact 4a into contact with the substrate 1. The configuration of the contact portion 61a is not particularly limited, but for example, a contact terminal such as a contact spring, a conductive screw, or the like may be used.

[0038] The connection circuit 62a is connected between the contact portion 61a and the ground GND. The connection circuit 62a defines a connection state between the contact portion 61a and the ground GND, that is, a connection state between the contact 4a of the parasitic antenna element 4 and the ground GND. Various definition of the connection state enables the parasitic antenna element 4 to have more resonance frequencies.

[0039] Examples of the connection state include a state (short-circuit state) in which the contact 4a is connected to the ground GND and a state (e.g., open state) in which the contact 4a is not connected to the ground GND. The connection circuit 62a may define the connection state for each frequency band. For example, the connection circuit 62a brings the contact 4a into the short-circuit state in a specific frequency band and brings the contact 4a into the open state in another frequency band. The connection circuit 62a having such a configuration includes, for example, a filter. An example of a filter includes a bandpass filter that passes a signal in the specific frequency band. For the filter, a filter circuit configured to include coils and/or capacitors provided in series and/or in parallel may be used.

[0040] Other examples of the connection state include an impedance and a phase from the contact 4a to the

ground GND. This impedance and phase adjust the electrical length of the first portion 41 of the parasitic antenna element 4, and further the resonance frequency of the first portion 41. The connection circuit 62a may define the connection state according to the frequency band used. For example, the connection circuit 62a adjusts the impedance and the phase from the contact 4a to the ground GND so that the resonance frequency of the first portion 41 of the parasitic antenna element 4 is included in the frequency band used. The connection circuit 62a having such a configuration includes an active element. An example of the active element is a switch such as SP4T. The switch is provided so as to provide a plurality of paths from the contact 4a to the ground GND. Circuit elements and the like may be provided on several paths so that the paths have different impedances and phases. The switch switches the impedances and the phases from the contact 4a to the ground GND. The antenna device 100 may also include a control unit and the like necessary for switch control.

[0041] The connection circuit 62a may have a configuration in which both configurations of the filter and the switch described above are combined.

[0042] The connection unit 6b is a second connection unit that is provided between the contact 4b and the ground GND. The connection unit 6b includes a contact portion 61b and a connection circuit 62b. The contact portion 61b brings the contact 4b into contact with the substrate 1. The connection circuit 62b defines a connection state between the contact portion 61b and the ground GND, that is, a connection state between the contact 4b of the parasitic antenna element 4 and the ground GND. Details are similar to those of the contact portion 61a and connection circuit 62a described above, and thus the description thereof will not be repeated. A specific frequency band (e.g., passband of the filter) in which the connection circuit 62b changes the connection state into the short-circuit state may be a frequency band different from the specific frequency band in the connection circuit 62a described above.

[0043] The connection unit 6c is a third connection unit that is provided between the contact 4c and the ground GND. The connection unit 6c includes a contact portion 61c and a connection circuit 62c. The contact portion 61c brings the contact 4c into contact with the substrate 1. The connection circuit 62c defines a connection state between the contact portion 61c and the ground GND, that is, a connection state between the contact 4c of the parasitic antenna element 4 and the ground GND. Details are similar to those of the contact portion 61a and connection circuit 62a described above, and thus the description thereof will not be repeated. A specific frequency band in which the connection circuit 62c changes the connection state into the short-circuit state may be a frequency band different from the specific frequency band in the connection circuit 62a described above and the specific frequency band in the connection circuit 62b.

[0044] Returning to FIG. 1, the additional parasitic antenna element 5 will be described. The additional parasitic antenna element 5 is a parasitic antenna element different from the parasitic antenna element 4, and is provided on the substrate 1 in this example. One end portion of the additional parasitic antenna element 5 (end portion on a side near the feed antenna element 3, in this example) is connected to the ground GND. The additional parasitic antenna element 5 is electrically coupled to the feed antenna element 3 via the substrate 1. Examples of the additional parasitic antenna element 5 include an LDS antenna, a metal pattern formed on the substrate 1, and the like. The metal pattern is provided at a portion of the substrate 1 having no pattern of the ground GND. The LDS antenna may be provided at a portion of the substrate 1 having the pattern of the ground GND, or may be provided at a portion of the substrate 1 having no pattern of the ground GND.

[0045] The additional parasitic antenna element 5 has a resonance frequency different from the resonance frequency of the feed antenna element 3 and the resonance frequency of the parasitic antenna element 4. Similarly to the resonance frequencies of the feed antenna element 3 and the parasitic antenna element 4, the resonance frequency of the additional parasitic antenna element 5 is also a frequency in the frequency band used for the antenna device 100. The resonance frequency of the additional parasitic antenna element 5 may be a frequency included in a band different from the band including the resonance frequency of the feed antenna element 3 and the band including the resonance frequency of the parasitic antenna element 4. The resonance frequency of the additional parasitic antenna element 5 may be lower than the resonance frequency of the feed antenna element 3.

[0046] In the antenna device 100 having the configuration described above, a plurality of coexistent resonant modes can coexist. Examples of some resonant modes will be described with reference to FIG. 3.

[0047] FIG. 3 is a table illustrating an example of a plurality of resonant modes. Exemplified are six resonant modes of a resonant mode M1 to a resonant mode M6 are exemplified.

[0048] The resonant mode M1 is a mode of resonance at a frequency (first resonance frequency) at which the electrical length of the whole parasitic antenna element 4 is $\lambda/2$. An example of the first resonance frequency is a frequency in a 700 MHz band. At the first resonance frequency, the contact 4a is in the short-circuit state. The contact 4b is in the open state. The contact 4c is in the short-circuit state.

[0049] The resonant mode M2 is a mode of resonance at a frequency (second resonance frequency) at which the electrical length of the first portion 41 of the parasitic antenna element 4 is $\lambda/2$. An example of the resonance frequency is a frequency in a 1800 MHz band. At the second resonance frequency, the contact 4a is in the short-circuit state. The contact 4b is in the short-circuit state. The contact 4c is in any state. In order to avoid

unexpected unnecessary resonance or the like, the short-circuit state may be adopted, as any state.

[0050] The resonant mode M3 is a mode of resonance at a frequency (third resonance frequency) at which the electrical length of the first portion 41 of the parasitic antenna element 4 is λ/4. An example of the third resonance frequency is a frequency in a 900 MHz band. At the third resonance frequency, the contact 4a is in the open state. The contact 4b is in the short-circuit state. The contact 4c is in any state.

[0051] The resonant mode M4 is a mode of resonance at a frequency (fourth resonance frequency) at which the electrical length of the second portion 42 of the parasitic antenna element 4 is λ/2. An example of the fourth resonance frequency is a frequency in a 1500 MHz band. At the fourth resonance frequency, the contact 4a is in any state. The contact 4b is in the short-circuit state. The contact 4c is in the short-circuit state.

[0052] The resonant mode M5 is a mode of resonance at a frequency (fifth resonance frequency) at which the electrical length of the feed antenna element 3 is λ/4. An example of the fifth resonance frequency is a frequency in a 3500 MHz band. At the fifth resonance frequency, the contact 4a is in the short-circuit state. The contact 4b is in the short-circuit state. The contact 4c is in any state.

[0053] The resonant mode M6 is a mode of resonance at a frequency (sixth resonance frequency) at which the electrical length of the additional parasitic antenna element 5 is λ/4. An example of the sixth resonance frequency is a frequency in a 2500 MHz band. At the sixth resonance frequency, the contact 4a is in any state. The contact 4b is in any state. The contact 4c is in any state.

[0054] As described above, the connection circuit 62a, the connection circuit 62b, and the connection circuit 62c define the connection state for each frequency band. In the example illustrated in FIG. 3, the connection circuit 62a brings the contact 4a into the short-circuit state in the 700 MHz band, 1800 MHz band, and 3500 MHz band, and brings the contact 4a into the open state in the 900 MHz band. The connection circuit 62b brings the contact 4b into the short-circuit state in the 1800 MHz band, 900 MHz band, 1500 MHz band, and 3500 MHz band, and brings the contact 4b into the open state in the 700 MHz band. The connection circuit 62c brings the contact 4c into the short-circuit state in the 700 MHz band and 1500 MHz band. When the connection circuit 62a or the like adjusts the impedance and the phase between the contact 4a or the like and the ground GND, for example, the first resonance frequency to the fourth resonance frequency can be also adjusted.

[0055] For example, the plurality of resonant modes as described above makes it possible for the antenna device 100 to support multiple bands. In addition, using the housing 2 including the parasitic antenna element 4 makes it possible to reduce the size of the antenna device 100, as compared with providing the parasitic antenna element 4 separately from the housing 2.

[0056] The embodiments of the present disclosure have been described above, but the technical scope of the present disclosure is not limited to the embodiments described above, and various modifications and alterations can be made without departing from the spirit and scope of the present disclosure. Some examples will be described.

[0057] Some of the connection units may not include the connection circuits. For example, in a case where the connection unit 6c does not include the connection circuit 62c, the contact portion 61c may be directly connected to the ground GND. Even in this case, the connection state of the contact 4c can be defined for each frequency band described above with reference to FIG. 3.

[0058] The number and positions of the contacts provided in the parasitic antenna element 4 are not limited to the contact 4a, the contact 4b, and the contact 4c. Any number of contacts may be provided at any position.

[0059] A plurality of the additional parasitic antenna elements 5 may be provided.

[0060] The frequency band including the resonance frequency is not limited to the specific frequency band described above with the numerical values.

[0061] The antenna device 100 may be used by being incorporated into various devices such as a radar device, in addition to the communication apparatus.

2. Effects

[0062] The antenna device 100 having described above is specified, for example, as follows. As described with reference to FIGS. 1 and 3 and the like, the antenna device 100 includes the feed antenna element 3, and the housing 2 that includes the parasitic antenna element 4 extending to be electrically coupled to the feed antenna element 3 and that has a resonance frequency different from that of the feed antenna element 3.

[0063] According to the antenna device 100 described above, the resonance frequency of the feed antenna element 3 and the resonance frequency of the parasitic antenna element 4 included in the housing 2 coexist, and therefore, multiple bands can be supported. Furthermore, the size of the antenna device 100 can be reduced, as compared with providing a parasitic antenna element separately from the housing 2.

[0064] As described with reference to FIG. 2 and the like, the antenna device 100 may include the connection unit 6a, the connection unit 6b, and the connection unit 6c that are provided between the parasitic antenna element 4 and the ground GND. This configuration makes it possible to ensure the ground of the parasitic antenna element 4 so that the parasitic antenna element 4 can have a resonance frequency according to itself.

[0065] As described with reference to FIGS. 2 and 3 and the like, the connection unit 6a, the connection unit 6b, and the connection unit 6c may include the connection circuit 62a, the connection circuit 62b, and the connection circuit 62c each of which defines the connection state between the parasitic antenna element 4 and the

ground GND. The connection circuit 62a, the connection circuit 62b, and the connection circuit 62c may each include the filter that defines the connection state for each frequency band, or may each include the switch that defines the connection state according to the frequency band used. This configuration makes it possible for the parasitic antenna element 4 to have more resonance frequencies.

[0066] As described with reference to FIG. 1 and the like, the feed antenna element 3 may include the base portion 31 that has the feed point 3a, and the extending portion 32 that extends from the end portion of the base portion 31 to both sides. For example, an antenna having such a T-shape can be used as the feed antenna element 3.

[0067] As described with reference to FIG. 1 and the like, the parasitic antenna element 4 may include the first portion 41 that extends along the extending direction of the feed antenna element 3 so as to generate capacitive coupling with the feed antenna element 3, and the second portion 42 that contiguously extends from the first portion 41. For example, in this way, the parasitic antenna element 4 can be electrically coupled to the feed antenna element 3.

[0068] As described with reference to FIG. 1 and the like, the length of the first portion 41 of the parasitic antenna element 4 may be longer than the length of the feed antenna element 3. Therefore, electrical coupling between the first portion 41 of the parasitic antenna element 4 and the feed antenna element 3 can be enhanced.

[0069] As described with reference to FIGS. 1 and 2 and the like, the connection unit 6a may be the first connection unit that is provided between the ground GND and one end portion (portion where the contact 4a is provided) of the first portion 41 of the parasitic antenna element 4. The connection unit 6b may be the second connection unit that is provided between the ground GND and the other end portion (portion where the contact 4b is provided) of the first portion 41 of the parasitic antenna element 4. The connection unit 6c may be the third connection unit that is provided between the ground GND and the end portion (portion where the contact 4b is provided) of the second portion 42 of the parasitic antenna element 4, provided on the opposite side of the first portion 41. For example, providing a plurality of the connection units 6a, 6b, and 6c having such configurations makes it possible for the parasitic antenna element 4 to have many resonance frequencies.

[0070] The parasitic antenna element 4 may have a resonance frequency that is lower than the resonance frequency of the feed antenna element 3. Therefore, for example, it is possible to couple the feed antenna element 3 to the parasitic antenna element 4, as the transmission path, without interfering with the radiation of the feed antenna element 3 alone.

[0071] As described with reference to FIGS. 1 and 3 and the like, the antenna device 100 may include the additional parasitic antenna element 5 that is electrically coupled to the feed antenna element 3 and that has a resonance frequency different from the resonance frequency of the parasitic antenna element 4 and the resonance frequency of the additional parasitic antenna element 5. The additional parasitic antenna element 5 may be electrically coupled to the feed antenna element 3 via the substrate 1. The additional parasitic antenna element 5 may have a resonance frequency that is lower than the resonance frequency of the feed antenna element 3. Providing the additional parasitic antenna element 5 having such a configuration makes it possible to increase the number of coexisting resonance frequencies, and further multiple bands can be supported.

[0072] According to an aspect of the present disclosure, the communication apparatus is also provided to perform communication by using the antenna device 100. In other words, the communication apparatus includes the feed antenna element 3, and the housing 2 that includes the parasitic antenna element 4 extending to be electrically coupled to the feed antenna element 3 and that has a resonance frequency different from that of the feed antenna element 3, and the communication apparatus performs communication by using the feed antenna element 3. Even in the communication apparatus having such a configuration, it is possible to support multiple bands and to reduce the size of the device.

[0073] Note that the effects described in the present disclosure are merely examples and the effects are not limited to those disclosed. Other effects may be provided. Power may be supplied to the parasitic antenna element 4. For example, power may be fed to the parasitic antenna element 4 (second antenna element) may be performed, together with power feeding to the feed antenna element 3 (first antenna element) or instead of power feeding to the feed antenna element 3. Even in this configuration, it is possible to support multiple bands and reduce the size of the device.

[0074] Note that the present technology can also employ the following configurations.

(1) An antenna device comprising:

a feed antenna element; and
a housing that includes a parasitic antenna element extending to be electrically coupled to the feed antenna element and having a resonance frequency different from that of the feed antenna element.

(2) The antenna device according to (1), further comprising
a connection unit that is provided between the parasitic antenna element and a ground.

(3) The antenna device according to (2), wherein
the connection unit includes a connection circuit that defines a connection state between the parasitic antenna element and the ground.

(4) The antenna device according to (3), wherein

the connection circuit includes a filter that defines the connection state for each frequency band.

(5) The antenna device according to (3) or (4), wherein

the connection circuit includes a switch that defines the connection state according to a frequency band used.

(6) The antenna device according to any one of (1) to (5), wherein

the feed antenna element includes:
a base portion that has a feed point; and
an extending portion that extends from an end portion of the base portion to both sides.

(7) The antenna device according to any one of (1) to (6), wherein

the parasitic antenna element includes:

a first portion that extends along an extending direction of the feed antenna element so as to generate capacitive coupling with the feed antenna element; and
a second portion that contiguously extends from the first portion.

(8) The antenna device according to (7), wherein

a length of the first portion of the parasitic antenna element is longer than a length of the feed antenna element.

(9) The antenna device according to (7) or (8), further comprising

a plurality of connection units that are connected between the parasitic antenna element and a ground,
wherein the plurality of connection units includes:

a first connection unit that is provided between one end portion of the first portion of the parasitic antenna element and the ground; and
a second connection unit that is provided between the other end portion of the first portion of the parasitic antenna element and the ground.

(10) The antenna device according to (9), wherein

the plurality of connection units includes a third connection unit that is provided between the ground and an end portion of the second portion of the parasitic antenna element provided on a side opposite to the first portion.

(11) The antenna device according to any one of (1) to (10), wherein

the resonance frequency of the parasitic antenna element is lower than the resonance frequency of the feed antenna element.

(12) The antenna device according to any one of (1) to (11), further comprising

an additional parasitic antenna element that is electrically coupled to the feed antenna element and that has a resonance frequency different from the resonance frequency of the feed antenna element and the resonance frequency of the parasitic antenna element.

(13) The antenna device according to (12), wherein

the additional parasitic antenna element is electrically coupled to the feed antenna element via a substrate.

(14) The antenna device according to (12) or (13), wherein

the resonance frequency of the additional parasitic antenna element is lower than the resonance frequency of the feed antenna element.

(15) A communication apparatus comprising:

a feed antenna element; and
a housing that includes a parasitic antenna element extending to be electrically coupled to the feed antenna element and having a resonance frequency different from that of the feed antenna element,
wherein communication is performed by using the feed antenna element.

Reference Signs List

[0075]

1	SUBSTRATE
2	HOUSING
21	HOUSING
22	HOUSING
3	FEED ANTENNA ELEMENT
31	BASE PORTION
32	EXTENDING PORTION
33	EXTENDING PORTION
34	EXTENDING PORTION
4	PARASITIC ANTENNA ELEMENT
41	FIRST PORTION
42	SECOND PORTION
4a	CONTACT
4b	CONTACT
4c	CONTACT
5	ADDITIONAL PARASITIC ANTENNA ELEMENT
6a	CONNECTION UNIT
6b	CONNECTION UNIT
6c	CONNECTION UNIT
61a	CONTACT PORTION
61b	CONTACT PORTION
61c	CONTACT PORTION
62a	CONNECTION CIRCUIT
62b	CONNECTION CIRCUIT
62c	CONNECTION CIRCUIT

100 ANTENNA DEVICE (COMMUNICATION APPARATUS)

Claims

1. An antenna device comprising:

a feed antenna element; and
a housing that includes a parasitic antenna element extending to be electrically coupled to the feed antenna element and having a resonance frequency different from that of the feed antenna element.

2. The antenna device according to claim 1, further comprising
a connection unit that is provided between the parasitic antenna element and a ground.

3. The antenna device according to claim 2, wherein
the connection unit includes a connection circuit that defines a connection state between the parasitic antenna element and the ground.

4. The antenna device according to claim 3, wherein
the connection circuit includes a filter that defines the connection state for each frequency band.

5. The antenna device according to claim 3, wherein
the connection circuit includes a switch that defines the connection state according to a frequency band used.

6. The antenna device according to claim 1, wherein
the feed antenna element includes:

a base portion that has a feed point; and
an extending portion that extends from an end portion of the base portion to both sides.

7. The antenna device according to claim 1, wherein
the parasitic antenna element includes:

a first portion that extends along an extending direction of the feed antenna element so as to generate capacitive coupling with the feed antenna element; and
a second portion that contiguously extends from the first portion.

8. The antenna device according to claim 7, wherein
a length of the first portion of the parasitic antenna element is longer than a length of the feed antenna element.

9. The antenna device according to claim 7, further comprising
a plurality of connection units that are connected between the parasitic antenna element and a ground,
wherein the plurality of connection units includes:

a first connection unit that is provided between one end portion of the first portion of the parasitic antenna element and the ground; and
a second connection unit that is provided between the other end portion of the first portion of the parasitic antenna element and the ground.

10. The antenna device according to claim 9, wherein
the plurality of connection units includes a third connection unit that is provided between the ground and an end portion of the second portion of the parasitic antenna element provided on a side opposite to the first portion.

11. The antenna device according to claim 1, wherein
the resonance frequency of the parasitic antenna element is lower than the resonance frequency of the feed antenna element.

12. The antenna device according to claim 1, further comprising
an additional parasitic antenna element that is electrically coupled to the feed antenna element and that has a resonance frequency different from the resonance frequency of the feed antenna element and the resonance frequency of the parasitic antenna element.

13. The antenna device according to claim 12, wherein
the additional parasitic antenna element is electrically coupled to the feed antenna element via a substrate.

14. The antenna device according to claim 12, wherein
the resonance frequency of the additional parasitic antenna element is lower than the resonance frequency of the feed antenna element.

15. A communication apparatus comprising:

a feed antenna element; and
a housing that includes a parasitic antenna element extending to be electrically coupled to the feed antenna element and having a resonance frequency different from that of the feed antenna element,
wherein communication is performed by using the feed antenna element.

FIG.1

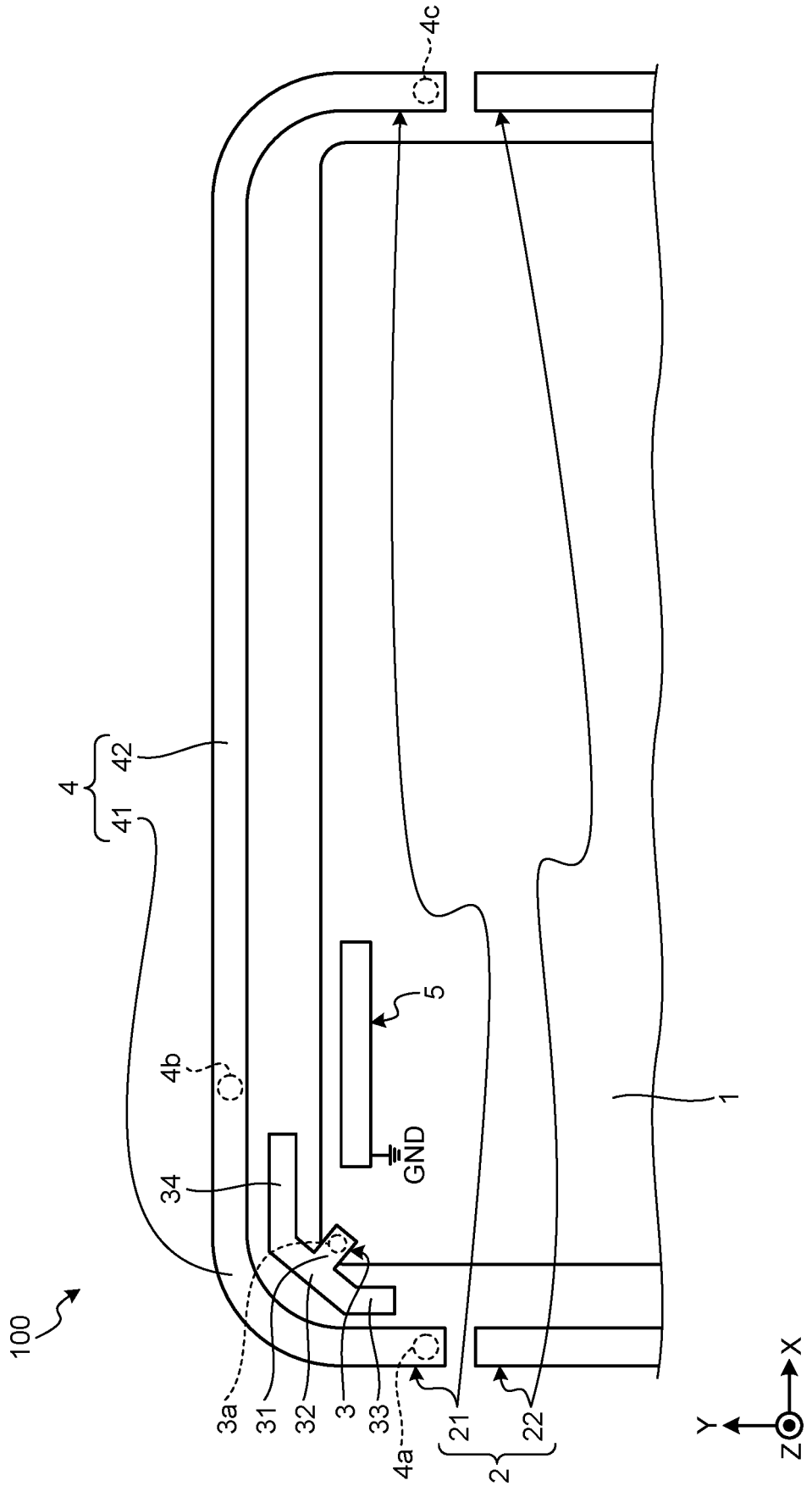

FIG.2

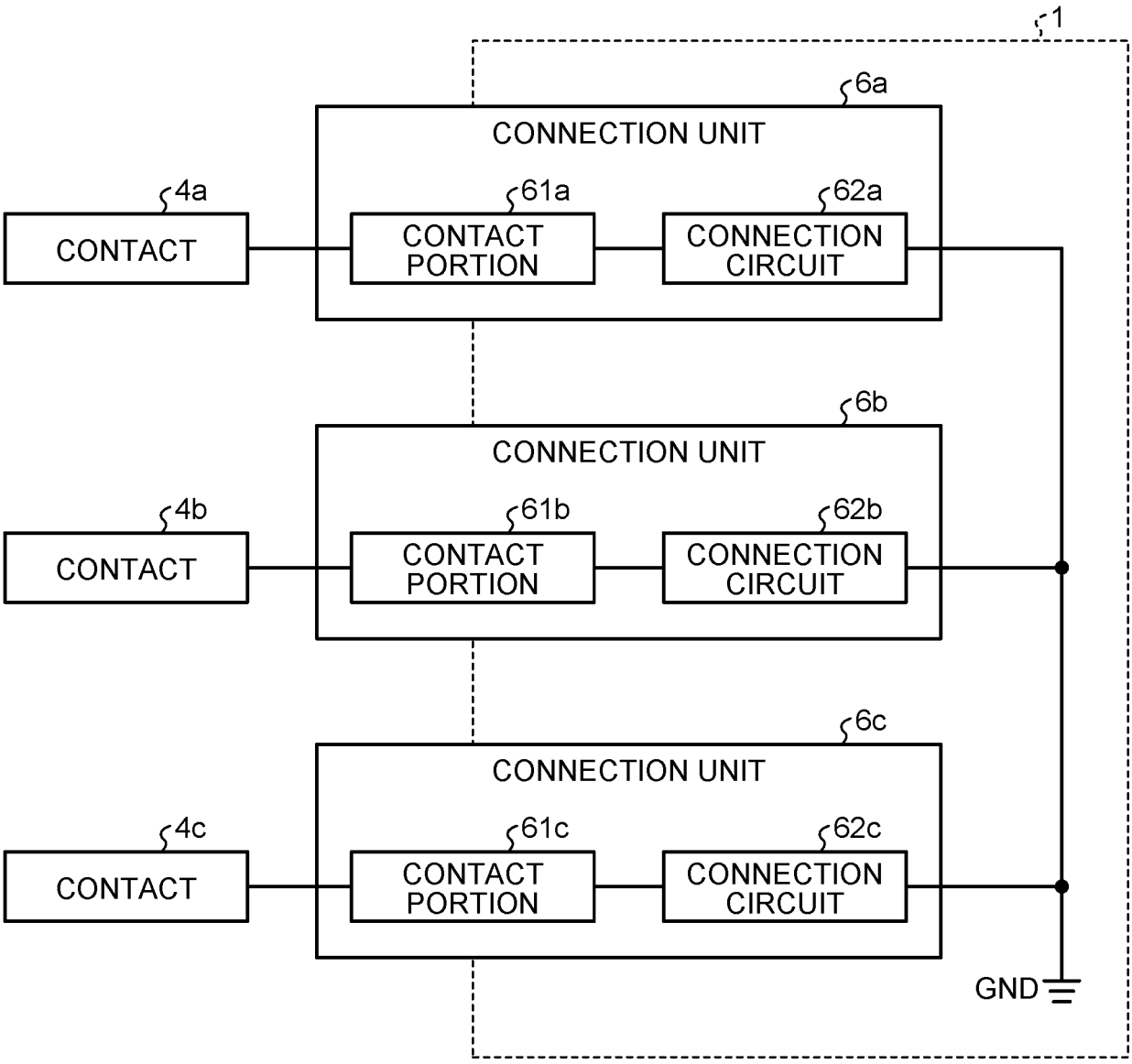
1
6a
CONNECTION UNIT
4a
CONTACT
61a
CONTACT PORTION
62a
CONNECTION CIRCUIT
6b
CONNECTION UNIT
4b
CONTACT
61b
CONTACT PORTION
62b
CONNECTION CIRCUIT
6c
CONNECTION UNIT
4c
CONTACT
61c
CONTACT PORTION
62c
CONNECTION CIRCUIT
GND

FIG.3

RESONANT MODE	FREQUENCY BAND	CONNECTION CIRCUIT 62a/ CONTACT 4a	CONNECTION CIRCUIT 62b/ CONTACT 4b	CONNECTION CIRCUIT 62c/ CONTACT 4c	RESONANT ELECTRICAL LENGTH
RESONANT MODE M1	700MHz	SHORT-CIRCUIT STATE	OPEN STATE	SHORT-CIRCUIT STATE	λ /2
RESONANT MODE M2	1800MHz	SHORT-CIRCUIT STATE	SHORT-CIRCUIT STATE	ANY STATE	λ /2
RESONANT MODE M3	900MHz	OPEN STATE	SHORT-CIRCUIT STATE	ANY STATE	λ /4
RESONANT MODE M4	1500MHz	ANY STATE	SHORT-CIRCUIT STATE	SHORT-CIRCUIT STATE	λ /2
RESONANT MODE M5	3500MHz	SHORT-CIRCUIT STATE	SHORT-CIRCUIT STATE	ANY STATE	λ /4
RESONANT MODE M6	2500MHz	ANY STATE	ANY STATE	ANY STATE	λ /4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/037614

A. CLASSIFICATION OF SUBJECT MATTER
H01Q 5/378(2015.01)i
FI: H01Q5/378
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01Q5/378

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2016/0056545 A1 (SAMSUNG ELECTRONICS CO., LTD.) 25 February 2016 (2016-02-25) paragraphs [0078], [0085], [0111], fig. 2, 4, 6-7	1-3, 5-11, 15 1-15
Y	WO 2004/047223 A1 (YOKOWO CO., LTD.) 03 June 2004 (2004-06-03) fig. 4	4
Y	JP 2010-232820 A (NEC CORP.) 14 October 2010 (2010-10-14) fig. 4	12-14
Y	JP 2015-533047 A (QUALCOMM INCORPORATED) 16 November 2015 (2015-11-16) fig. 2	1-15
A	CN 106785421 A (YULONG COMPUTER TELECOMMUNICATION SCIENT CO., LTD.) 31 May 2017 (2017-05-31)	1-15
A	CN 109462016 A (OPPO GUANGDONG MOBILE TELECOMMUNICATIONS CO., LTD.) 12 March 2019 (2019-03-12)	1-15

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 02 December 2020 (02.12.2020)	Date of mailing of the international search report 15 December 2020 (15.12.2020)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application no.
PCT/JP2020/037614

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
US 2016/0056545 A1	25 Feb. 2016	KR 10-2016-0024428 A	
WO 2004/047223 A1	03 Jun. 2004	US 2006/0097918 A1 fig. 4	
JP 2010-232820 A	14 Oct. 2010	(Family: none)	
JP 2015-533047 A	16 Nov. 2015	US 2015/0222020 A1 fig. 2 WO 2014/046691 A1	
CN 106785421 A	31 May 2017	(Family: none)	
CN 109462016 A	12 Mar. 2019	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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