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(54) **DUAL BAND ANTENNA**

(57) A dual band antenna (1) for feeding a first and a second resonant signals includes a first antenna part (11) and a second antenna part (12). A frequency of the second resonant signal is higher than a frequency of the first resonant signal. The first antenna part (11) includes a first radiation unit (111) and a second radiation unit (112), in which an angle is formed. The second antenna part (12) includes a first sub-radiator (121) and a second

sub-radiator (122). A length of the first radiation unit (111) and a length of the second radiation unit (112) are respectively related to a wavelength of the second resonant signal and a wavelength of the first resonant signal. Being arranged between the first antenna part (11) and the first sub-radiator (121), the second sub-radiator (122) is shorter than the second radiation segment.

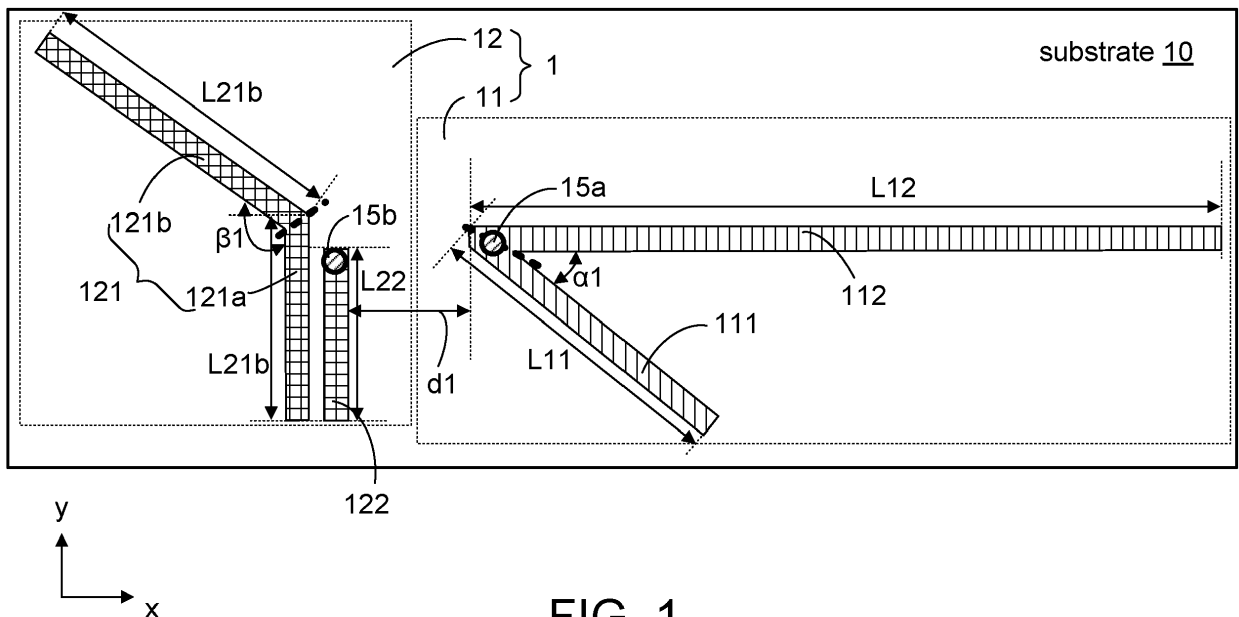


FIG. 1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a dual band antenna, and more particularly to a dual band dipole antenna capable of improving the bandwidth of a resonant signal.

BACKGROUND OF THE INVENTION

[0002] With increasing development of networking technologies, wireless communication is closely correlated with the lives of most people. Consequently, the portable electronic device with the wireless communication function becomes the mainstream of the market. For providing the wireless communication function, the portable electronic device has to be equipped with a built-in antenna or an external antenna. Moreover, the portable electronic device receives a radio frequency signal from the surroundings through the antenna. In views of small size and light weightness, the antenna used in the portable electronic device should have the miniature design. That is, the main body of the antenna should be as small as possible.

[0003] As the demands on the practicality and technicality of the wireless communication products are gradually increased, the wideband and multi-band wireless communication products are introduced into the market. In other words, the portable electronic device with the wireless communication function needs to support various wireless communication standards. In case that the portable electronic device uses the small-sized antenna, the antenna has to receive the radio frequency signals in different frequency bands.

SUMMARY OF THE INVENTION

[0004] The present invention relates to a dual band antenna, and more particularly to a dual band dipole antenna capable of improving the bandwidth of a resonant signal. The dual band antenna is capable of improving the bandwidth of the low-frequency resonant signal through a coupling segment and improving the bandwidth of the high-frequency resonant signal through an inclined segment.

[0005] An embodiment of the present invention provides a dual band antenna. The dual band antenna is used for feeding a first resonant signal and a second resonant signal. A frequency of the second resonant signal is higher than a frequency of the first resonant signal. The dual band antenna includes a first antenna part and a second antenna part. The first antenna part includes a first radiation unit and a second radiation unit. A length of the first radiation unit is related to a wavelength of the first resonant signal. The second radiation unit is connected with the first radiation unit. A first angle is formed between the second radiation unit and the first

radiation unit. A length of the second radiation unit is related to a wavelength of the second resonant signal. The second antenna part includes a first sub-radiator and a second sub-radiator. The first sub-radiator includes a coupling segment and an extension segment. A second angle is formed between the coupling segment and the extension segment. The second sub-radiator is arranged between the first antenna part and the first sub-radiator. At least a portion of the second sub-radiator is in parallel with the coupling segment.

[0006] Numerous objects, features and advantages of the present invention will be readily apparent upon a reading of the following detailed description of embodiments of the present invention when taken in conjunction with the accompanying drawings. However, the drawings employed herein are for the purpose of descriptions and should not be regarded as limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The above objects and advantages of the present invention will become more readily apparent to those ordinarily skilled in the art after reviewing the following detailed description and accompanying drawings, in which:

FIG. 1 schematically illustrates a dual band dipole antenna according to an embodiment of the present invention;

FIG. 2 schematically illustrates the length relationship between the two radiation units of the first antenna part of the dual band dipole antenna according to the embodiment of the present invention;

FIGS. 3A and 3B schematically illustrates two examples of the first radiation unit of the first antenna part of the dual band dipole antenna according to the embodiment of the present invention;

FIGS. 4A, 4B, 4C and 4D schematically illustrates four examples of the second radiation unit of the first antenna part of the dual band dipole antenna according to the embodiment of the present invention;

FIG. 5 schematically illustrates the length relationship between the two sub-radiators units of the second antenna part of the dual band dipole antenna according to the embodiment of the present invention;

FIGS. 6A and 6B schematically illustrates two examples of the first sub-radiator of the second antenna part of the dual band dipole antenna according to the embodiment of the present invention;

FIGS. 7A and 7B schematically illustrates two examples of the second sub-radiator of the second antenna

na part of the dual band dipole antenna according to the embodiment of the present invention;

FIG. 8 is an implementation example of the dual band dipole antenna according to the embodiment of the present invention;

FIG. 9A is an implementation example illustrating the first antenna part of the dual band dipole antenna as shown in FIG. 8;

FIG. 9B is an implementation example illustrating the second antenna part of the dual band dipole antenna as shown in FIG. 8;

FIG. 9C schematically illustrates the relative positions between the second antenna part and the first antenna part of the dual band dipole antenna as shown in FIG. 8;

FIG. 10A schematically illustrates the current paths of the dual band dipole antenna when the first resonant signal is fed into the dual band dipole antenna; and

FIG. 10B schematically illustrates the current paths of the dual band dipole antenna when the second resonant signal is fed into the dual band dipole antenna.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0008] For designing an antenna, the multi-band applications are usually taken into considerations. In case that a wireless transmission module of a portable electronic device complies with the 802.11b and 802.11 a protocols of the wireless local area network (WLAN) standard, the structure or the circuit of the antenna structure needs to be operated in the 2.4GHz frequency band and the 5GHz frequency band. Generally, the antenna capable of receiving the wireless communication signals in two different frequency bands is referred as a dual band antenna.

[0009] For feeding the resonant signal, the structure of the dual band antenna has to exhibit resonance. In the following examples, the first resonant signal has a first resonant frequency f_1 (e.g., 2.4GHz), and the second resonant signal has a second resonant frequency f_2 (e.g., 5GHz). The parameters of the dual band antenna will be described as follows. It is noted that the frequencies of the resonant signals may be varied according to the practical requirements. Consequently, the length, angle and any other appropriate parameters of the dual band antenna are adjustable.

[0010] In an embodiment, the dual band antenna exhibits the resonance when the length of the radiator of the dual band antenna is an integral multiple of the 1/4

wavelength of the resonant signal. Due to the resonance, the radiator and the feeding part of the antenna match each other. In case that the first resonant signal has the first resonant frequency f_1 (e.g., 2.4GHz), the one fourth of the first resonant wavelength λ_1 is 31.25mm (i.e., $1/4 \times \lambda_1 = 12.5\text{cm}/4 = 31.25\text{mm}$). In case that the second resonant signal has the second resonant frequency f_2 (e.g., 5GHz), the one fourth of the second resonant wavelength λ_2 is 15mm (i.e., $1/4 \times \lambda_2 = 6\text{cm}/4 = 15\text{mm}$). The length parameters of the dual band parameters are determined according to the $1/4 \times \lambda_1$ and the $1/4 \times \lambda_2$. In some other embodiments, the length of the dual band antenna is related to $1/1 \times \lambda_1$, $1/1 \times \lambda_2$, $1/2 \times \lambda_1$ or $1/2 \times \lambda_2$. **[0011]** FIG. 1 schematically illustrates a dual band dipole antenna according to an embodiment of the present invention. As shown in FIG 1, the dual band dipole antenna 1 includes a first feeding point 15a, a second feeding point 15b, a first antenna part 11 and a second antenna part 12. For clarification, the radiator of the first antenna part 11 is indicated by vertical lines, and the radiator of the second antenna part 12 is indicated by grids. The junction between every two adjacent segments is indicated by a bolt dotted line. The two adjacent segments are connected with each other.

[0012] In an embodiment, the substrate 10 is rectangular. The long side of the substrate 10 is in parallel with the x direction (or a first direction), and the short side of the substrate 10 is in parallel with the y direction (or a second direction). Preferably but not exclusively, the substrate is a single-sided printed circuit board, double-layered printed circuit board or multi-layered printed circuit board that is made of glass fiber. The radiators of the dual band dipole antenna 1 are made of metallic material or any other appropriate conductive material. In case that the substrate 10 is a double-layered printed circuit board or multi-layered printed circuit board, the side of the substrate opposite to the installation side of the dual band dipole antenna 1 cannot be provided with any metallic structure. Consequently, when the resonant signal is fed into the dual band dipole antenna 1, the dual band dipole antenna 1 is not interfered by the electronic components of the opposite side.

[0013] As shown in FIG. 1, the radiator of the dual band dipole antenna 1 has the strip-like design. That is, the length of the lateral side of the radiator is approximately equal to the length of the centerline of the radiator. In views of the layout convenience, the width of the radiator is uniformly distributed. In an embodiment, the width of the radiator is 1/1000 of the first resonant wavelength λ_1 . That is, the width of the radiator is equal to $12.5\text{cm}/1000 = 0.125\text{mm}$.

[0014] In an embodiment, the first antenna part 11 includes a single radiator, and the second antenna part 12 includes a first sub-radiator 121 and a second sub-radiator 122. The first sub-radiator 121 and the second sub-radiator 122 are in parallel with each other and separated from each other by a small distance. The second sub-radiator 122 is arranged between the first antenna part

11 and the first sub-radiator 121. Moreover, the second sub-radiator 122 is shorter than the first antenna part 11 and the first sub-radiator 121. The distance d1 between the second sub-radiator 122 and the first antenna part 11 is larger than or equal to 1 mm.

[0015] The first antenna part 11 is divided into a first radiation unit 111 and a second radiation unit 112. There is an angle α_1 between the second radiation unit 112 and the first radiation unit 111. The first sub-radiator 121 of the second antenna part 12 includes a coupling segment 121 a and a second extension segment 121 b. There is an angle β_1 between the coupling segment 121 a and the second extension segment 121 b. The coupling segment 121 a is in parallel with the second sub-radiator 122. Moreover, the coupling segment 121 a and the second sub-radiator 122 are very close to each other to result in a coupling effect.

[0016] The lengths, profiles and positions of the radiators of the dual band dipole antenna may be varied according to the practical requirements. Some variant examples of the first antenna part 11 and the second antenna part 12 will be described as follows. In some situations, the first antenna part 11 and the second antenna part 12 are designed according to the layout space of the substrate. Moreover, the radiators of different examples may be arbitrarily combined with each other.

[0017] FIG. 2 schematically illustrates the length relationship between the two radiation units of the first antenna part of the dual band dipole antenna according to the embodiment of the present invention. In an embodiment, the first radiation unit 111 of the first antenna part 11 is used with the second resonant signal, and the second radiation unit 112 of the first antenna part 11 is used with the first resonant signal. Consequently, the length L11 of the first radiation unit 111 is equal to one fourth of the second resonant wavelength, i.e., $L_{11}=1/4 \times \lambda_2$. Moreover, the length L12 of the second radiation unit 112 is equal to one fourth of the first resonant wavelength, i.e., $L_{12}=1/4 \times \lambda_1$.

[0018] As mentioned above, the first resonant frequency is 2.4GHz, and the second resonant frequency is 5GHz. That is, the length L11 of the first radiation unit 111 is about 15mm, and the length L12 of the second radiation unit 112 is about 31.25mm. The length L1 of the first antenna part 11 is equal to the sum of the length L11 of the first radiation unit 111 and the length L12 of the second radiation unit 112. That is, $L_1=L_{11}+L_{12}=1/4 \times (\lambda_1+\lambda_2)$. For example, $15\text{mm}+31.25\text{mm}=46.25\text{mm}$. Since the second resonant frequency is at least twice of the first resonant frequency, the wavelength of the first resonant signal is longer than twice of the wavelength of the first resonant signal. Consequently, as shown in FIG. 2, $1/4 \times \lambda_2 < 1/2 \times 1/4 \times \lambda_1$.

[0019] Two examples of the first radiation unit 111 are shown in FIGS. 3A and 3B. Four examples of the second radiation unit 112 are shown in FIGS. 4A, 4B, 4C and 4D. The examples of the first radiation unit 111 and the examples of the second radiation unit 112 may be arbi-

trarily combined with each other to define different first antenna parts 11.

[0020] As shown in FIG. 3A, the first radiation unit includes an inclined segment only. As shown in FIG. 3B, the first radiation unit includes an inclined segment and a bent segment.

[0021] Please refer to FIG. 3A. The first radiation unit 311 includes an inclined segment 3111 only. The length L11a of the inclined segment 3111 is equal to the length L11 of the first radiation unit 311. That is, $L_{11a}=L_{11}=1/4 \times \lambda_2$. Moreover, an angle α_2 between the inclined segment 3111 and the vertical direction is larger than 0 degree and smaller than 90 degrees.

[0022] Please refer to FIG. 3B. The first radiation unit 312 includes an inclined segment 3121 and a bent segment 3122. The sum of the length L11a of the inclined segment 3121 and the length L11 b of the bent segment 3122 is equal to the length L11 of the first radiation unit 312. That is, $L_{11a}+L_{11b}=L_{11}=1/4 \times \lambda_2$. The length L11a of the inclined segment 3121 is smaller than, equal to or larger than the length L11 b of the bent segment 3122.

[0023] Moreover, an inclined angle α_4 between the inclined segment 3121 and the vertical direction is larger than 0 degree, and an angle α_3 between the inclined segment 3121 and the bent segment 3122 is larger than or equal to 90 degrees (that is, an obtuse angle or a right angle). As the inclined segment 3121 is rotated in a counterclockwise direction with respect to the top end, the inclined angle α_4 is changed. Similarly, as the bent segment 3122 is rotated in a counterclockwise direction or a clockwise direction with respect to the junction between the bent segment 3122 and the inclined segment 3121, the angle α_3 is changed. In case that the angle α_3 is equal to 180 degrees, the first radiation unit 311 includes the inclined segment 3111. The rotating extents of the inclined segment 3121 and the bent segment 3122 are not restricted as long as the bent segment 3122 is not contacted with the second radiation unit.

[0024] In the embodiments as shown in FIGS. 4A and 4B, the second radiation unit includes a first extension segment only. In the embodiments as shown in FIGS. 4C and 4D, the second radiation unit includes a first extension segment and a vertical segment. Moreover, the length L12 of the second radiation unit is equal to $1/4 \times \lambda_1$ (e.g., 31.25mm).

[0025] Moreover, the first extension segment of FIG. 4A is an elongated straight segment without any turning angle. The first extension segment of FIG. 4B is a meandering segment with plural sub-segments, and a turning angle is formed between any two adjacent sub-segments. In the examples of FIGS. 4A and 4B, the length of the second radiation unit is equal to the length L12a of the first extension segment. Consequently, the length L12a of the first extension segment equal to one fourth of the first resonant wavelength λ_1 , i.e., $L_{12a}=1/4 \times \lambda_1$.

[0026] Please refer to FIG. 4A. As mentioned above, the second radiation unit 411 includes a first extension segment 4111 only, and the first extension segment 4111

is an elongated straight segment without any turning angle. Moreover, the first extension segment 4111 is extended along a horizontal direction. An angle α_5 between the first extension segment 4111 and the vertical direction is a right angle. That is, α_5 is 90 degrees.

[0027] Please refer to FIG. 4B. As mentioned above, the second radiation unit 4112 includes a first extension segment only, and the first extension segment is a meandering segment with plural sub-segments 4121 a, 4121b, 4121c, 4121d and 4121e. Moreover, a turning angle is formed between any two adjacent sub-segments. For example, the turning angle is 90 degrees.

[0028] Since the first extension segment is a meandering segment with plural sub-segments, the layout area of the dual band frequency on the substrate is reduced. It is noted that the number of the turning angles and the lengths of the sub-segments may be determined according to the practical requirements.

[0029] In the examples of FIGS. 4C and 4D, the second radiation unit includes a first extension segment and a vertical segment. Due to the vertical segment, the first radiation unit and the second radiation unit are not very close to each other. The first extension segment is longer than the vertical segment.

[0030] In the embodiments as shown in FIGS. 4C and 4D, the second radiation unit includes a first extension segment and a vertical segment. Moreover, the first extension segment of FIG. 4C is an elongated straight segment without any turning angle. The first extension segment of FIG. 4D is a meandering segment with plural sub-segments, and a turning angle is formed between any two adjacent sub-segments.

[0031] Please refer to FIG. 4C. As mentioned above, the second radiation unit 413 includes a first extension segment 4131 and a vertical segment 4132, and the first extension segment 4131 is an elongated straight segment without any turning angle. The length of the first extension segment 4131 is equal to L_{12a} . The length of the vertical segment 4132 is equal to L_{12b} . The overall length of the first extension segment 4131 and the vertical segment 4132 is equal to the length L_{12} of the second radiation unit 4131. That is, $L_{12a}+L_{12b}=L_{12}=1/4 \times \lambda_1$.

[0032] Please refer to FIG. 4D. As mentioned above, the second radiation unit 414 includes a first extension segment and a vertical segment 4142, and the first extension segment is a meandering segment with plural sub-segments 4141 a, 4141 b, 4141 c, 4141 d and 4141 e. Moreover, a turning angle is formed between any two adjacent sub-segments. In the drawing, only five sub-segments are shown. It is noted that the number of the turning angles and the lengths of the sub-segments may be determined according to the practical requirements.

[0033] FIG. 5 schematically illustrates the length relationship between the two sub-radiators units of the second antenna part of the dual band dipole antenna according to the embodiment of the present invention. The second antenna part 12 includes a first sub-radiator 121 and a second sub-radiator 122. Moreover, the length L_{22}

of the second sub-radiator 122 is shorter than the length L_{21} of the first sub-radiator 121. Due to the coupling effect between the coupling segment 121 a of the first sub-radiator 121 and the second sub-radiator 122, the overall length of the second antenna part 12 is shorter than $1/4 \times \lambda_1$. That is, $L_{21} + L_{22} = L_2 < 1/4 \times \lambda_1$.

[0034] The first sub-radiator 121 of the second antenna part 12 includes a coupling segment 121 a and a second extension segment 121b. The length L_{21} of the first sub-radiator 121 is equal to summation of the length L_{21a} of the coupling segment 121 a and the length L_{21b} of the second extension segment 121 b. That is, $L_{21} = (L_{21a} + L_{21b})$.

[0035] Two examples of the first sub-radiator 121 are shown in FIGS. 6A and 6B. Two examples of the second sub-radiator 122 are shown in FIGS. 7A and 7B.

[0036] Moreover, the second extension segment of the first sub-radiator as shown in FIG. 6A is an elongated straight segment without any turning angle. The second extension segment of the first sub-radiator as shown in FIG. 6B is a meandering segment with plural sub-segments, and a turning angle is formed between any two adjacent sub-segments.

[0037] Please refer to FIG. 6A. As mentioned above, the first sub-radiator 621 includes a coupling segment 6211 and a second extension segment 6212, and the second extension segment 6212 is an elongated straight segment without any turning angle. The coupling segment 6211 is in parallel with the vertical direction. The length of the coupling segment 6211 is equal to L_{21a} . The length of the second extension segment 6212 is equal to L_{21b} . The length L_{21} of the first sub-radiator 621 has to comply with the following relationship: $1/4 \times \lambda_2 < L_{21} < 1/4 \times \lambda_1$. The total length of the coupling segment 6211 and the second extension segment 6212 has to comply with the following relationship: $1/4 \times \lambda_2 < L_{21a} + L_{21b} = L_{21} < 1/4 \times \lambda_1$. An angle β_1 between the coupling segment 6211 and the second extension segment 6212 is in the range between 90 and 180 degrees. That is, $90 \leq \beta_1 \leq 180$.

[0038] Please refer to FIG. 6B. As mentioned above, the first sub-radiator 621 includes a coupling segment 6221 and a second extension segment, and the second extension segment is a meandering segment with plural sub-segments 6222a, 6222c and 6222d. Moreover, a turning angle is formed between any two adjacent sub-segments. It is noted that the number of the turning angles and the lengths of the sub-segments may be determined according to the practical requirements.

[0039] As mentioned in the examples of FIGS. 3B, 4B and 6B, the number of the turning angles and the lengths of the sub-segments in the first extension segment and/or the second extension segment are not restricted. For example, the sub-segments of the first extension segment and/or the second extension segment can be numbered from the left side to the right side. The odd-numbered sub-segments are in parallel with each other. Moreover, the even-numbered sub-segments are perpendicular to

the odd-numbered sub-segments.

[0040] The second sub-radiator as shown in FIG. 7A is a strip-shaped sub-radiator including a vertical segment only. The second sub-radiator as shown in FIG. 7B is an inverted L-shaped sub-radiator including a long segment and a short segment.

[0041] Please refer to FIG. 7A again. As mentioned above, the second sub-radiator 721 includes a long segment 721 a. The second feeding point (not shown) is located at the top end of the long segment 721 a. Moreover, the shortest distance between the second sub-radiator 721 and the first antenna part (not show) is equal to the distance between the right side of the long segment 721 a and the first antenna part.

[0042] Please refer to FIG. 7B again. As mentioned above, the second sub-radiator includes a long segment 722a and a short segment 722b. The length L22a of the long segment 722a is longer than the length L22b of the short segment 722b. An angle between the long segment 722a and the short segment 722b is a right angle (i.e., $\beta_2=90^\circ$). In case that the second sub-radiator as shown in FIG. 7B is an inverted L-shaped sub-radiator, the second feeding point (not shown) is located at the rightmost end of the short segment 722b. Under this circumstance, the shortest distance between the second sub-radiator 722 and the first antenna part (not show) is equal to the distance between the rightmost end of the short segment 722b and the first antenna part.

[0043] FIG. 8 is an implementation example of the dual band dipole antenna according to the embodiment of the present invention. The dual band dipole antenna 2 is installed on a substrate 20. Under control of a RF transceiver 29, a first resonant signal and a second resonant signal are fed into the dual band dipole antenna 2 and a coaxial cable 27 through a first feeding point 25a and a second feeding point 25b. A ground signal is fed to the first feeding point 25a, and an electromagnetic signal is fed to the second feeding point 25b.

[0044] For transmitting the resonant signals through the first feeding point 25a and the second feeding point 25b, currents are radiated as electromagnetic waves under the guidance of the transmission line (i.e., a waveguide). When the resonant signals are received through the first feeding point 25a and the second feeding point 25b, the electromagnetic energy is formed as the radio frequency energy by the dual band dipole antenna.

[0045] The second sub-radiator 222 and the coupling segment 221 a of the first sub-radiator 221 are collaboratively defined as a coupling structure. The length L22 of the second sub-radiator 222 is substantially equal to the length of the coupling segment 221 a of the first sub-radiator 221. In case that the second sub-radiator 222 is the strip-shaped sub-radiator including the long segment only, the length of the second sub-radiator 222 is shorter than or equal to the length of the coupling segment of the first sub-radiator. In case that the second sub-radiator is an inverted L-shaped sub-radiator, the length of the long segment is shorter than or equal to the length of the

coupling segment 221 a of the first sub-radiator 221. Under this circumstance, the length relationship between the second sub-radiator 222 and the coupling segment 221 a of the first sub-radiator 221 is influenced by the length of the short segment.

[0046] FIG. 9A is an implementation example illustrating the first antenna part of the dual band dipole antenna as shown in FIG. 8. Because of the inclined segment 211a, the resonant signal fed into the dual band dipole antenna has a wider bandwidth in the high frequency band. The simulation result shows that the bandwidth of the high-frequency resonant signal (e.g., the second resonant frequency 5GHz) is increased from 1150MHz to 1870 MHz. That is, the bandwidth improvement of the high-frequency resonant signal is 62.6% by the dual band dipole antenna. Since the feeding point is located at the inclined segment 211a, the short-circuited problem is avoided during the process of welding the feeding point. In this embodiment, the width w2 of the inclined segment 211 a is larger than the width w1 of the bent segment 211 b (i.e., $w_2 > w_1$).

[0047] FIG. 9B is an implementation example illustrating the second antenna part of the dual band dipole antenna as shown in FIG. 8. Since the second antenna part uses the coupling structure, the resonant signal fed into the dual band dipole antenna has a wider bandwidth in the low frequency band. The simulation result shows that the bandwidth of the low-frequency resonant signal (e.g., the first resonant frequency 2.4GHz) is increased from 100MHz to 120MHz. That is, the bandwidth improvement of the low-frequency resonant signal is 20% by the dual band dipole antenna.

[0048] As shown in FIG. 9B, the distance d2 between the second sub-radiator 222 and the coupling segment 221 a of the first sub-radiator 221 is smaller than 08.mm ($0 < d_2 < 0.8$). The length of the short segment 222b of the second sub-radiator 222 is in the range between 0mm and 3.2mm. The length of the long segment 222a is in the range between 7.25mm and 8.25mm. That is, the ratio of the length of the long segment 222a to the length of the short segment 222b is at least 2.578125.

[0049] Preferably, the width w1 of the bent segment 211 b, the width w3 of the first extension segment 212, the width w6 of the short segment 222b, the width w5 of the long segment 222a and the width w7 of the second extension segment 221 b are equal except for the width w2 of the inclined segment 211 a. Consequently, the layout convenience is enhanced.

[0050] In another embodiment, the width w5 of the long segment 222a is smaller than the width w2 of the inclined segment 211 a. However, the width w5 of the long segment 222a is larger than the width w6 of the short segment 222b, the width w1 of the bent segment 211 b, the width w3 of the first extension segment 212, the width w4 of the coupling segment 221 a of the first sub-radiator 221 and the width w7 of the second extension segment 221 b.

[0051] FIG. 9C schematically illustrates the relative po-

sitions between the second antenna part and the first antenna part of the dual band dipole antenna as shown in FIG. 8. The distance d3 is the shortest distance between the long segment 222a of the second sub-radiator 222 and the inclined segment 211 a. The distance d4 is the shortest distance between the rightmost end of the short segment 222b and the vertical segment 212a of the first antenna part 21. The distance d5 is the shortest distance between the inclined segment 211 a and the first extension segment 212. For facilitating installing the feeding points, the distance d3 and the distance d4 are at least 1mm, and the distance d5 is larger than 0mm. In practice, the shortest distance between the second sub-radiator 222 and the first radiation segment 221 is determined according to the required welding spaces of the feeding points. Consequently, the short circuit between the feeding points 25a and 25b is avoided.

[0052] As the frequency band is changed, the current path in the dual band dipole antenna is correspondingly changed. The current paths of the dual band dipole antenna corresponding to the resonant signals in the low frequency band and the high frequency band will be described in FIGS. 10A and 10B.

[0053] FIG. 10A schematically illustrates the current paths of the dual band dipole antenna when the first resonant signal is fed into the dual band dipole antenna. A first current CP11 flows through the second radiation unit of the first antenna part 21, and a second current CP12 flows through the first sub-radiator 221 and the second sub-radiator 222 of the second antenna part 22. According to the purpose of transmitting or receiving the first resonant signal under control of the RF transceiver 29, the directions of the first current CP11 and the second current CP12 are different. Regardless of the direction of the current, the intensity of the current is in inverse proportion to the distance from the corresponding feeding point. That is, the intensity of the first current CP11 near the first feeding point 25a and the second current CP12 near the second feeding point 25b are stronger.

[0054] FIG. 10B schematically illustrates the current paths of the dual band dipole antenna when the second resonant signal is fed into the dual band dipole antenna. A third current CP21 flows through the first radiation unit of the first antenna part 21, and a fourth current CP22 flows through the second sub-radiator 222 and a portion of the first sub-radiator 221. According to the purpose of transmitting or receiving the second resonant signal under control of the RF transceiver 29, the directions of the third current CP21 and the fourth current CP22 are different. Regardless of the direction of the current, the intensity of the current is in inverse proportion to the distance from the corresponding feeding point. That is, the intensity of the third current CP21 near the first feeding point 25a and the fourth current CP22 near the second feeding point 25b are stronger.

[0055] As shown in FIGS. 10A and 10B, the current path corresponding to the first resonant signal with the lower frequency (i.e., the paths of the first current CP11

and the second current CP12) is longer than the current path corresponding to the second resonant signal with the higher frequency (i.e., the paths of the third current CP21 and the fourth current CP22).

[0056] As mentioned above, the second resonant frequency is at least twice of the first resonant frequency. For example, in case that the first resonant frequency is 800/900MHz, the second resonant frequency is 1800MHz. In case that the first resonant frequency is 2400~2500MHz, the second resonant frequency is 5150~5850MHz.

[0057] Since the trend of designing the portable electronic device is toward miniaturization, the dual band dipole antenna is preferably built in a corner of a system circuit board of the portable electronic device. Alternatively, the substrate for installing the antenna is a small circuit board that is individually disposed on an inner wall of a casing of the electronic device and cooperatively used with a coaxial cable or a button-type RF connector. The dual band dipole antenna of the present invention can be applied to various wireless communication devices according to the practical requirements of the products.

[0058] While the invention has been described in terms of what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention needs not be limited to the disclosed embodiment. On the contrary, it is intended to cover various modifications and similar arrangements included within the spirit and scope of the appended claims which are to be accorded with the broadest interpretation so as to encompass all such modifications and similar structures.

35 Claims

1. A dual band antenna for feeding a first resonant signal and a second resonant signal, a frequency of the second resonant signal being higher than a frequency of the first resonant signal, **characterized in that** the dual band antenna comprises:

a first antenna part (11) comprising a first radiation unit (111) and a second radiation unit (112), wherein a length of the first radiation unit (111) is related to a wavelength of the second resonant signal, the second radiation unit (112) is connected with the first radiation unit (111), a first angle is formed between the second radiation unit (112) and the first radiation unit (111), and a length of the second radiation unit (112) is related to a wavelength of the first resonant signal; and
a second antenna part (12) comprising:

a first sub-radiator (121) comprising a coupling segment (121a) and an extension segment (121b), wherein a second angle is

- formed between the coupling segment (121 a) and the extension segment (121 b); and a second sub-radiator (122) arranged between the first antenna part (11) and the first sub-radiator (121), wherein at least a portion of the second sub-radiator (122) is in parallel with the coupling segment (121 a).
2. The dual band antenna as claimed in claim 1, **characterized in that** the first sub-radiator (121) is longer than the second sub-radiator (122), and a distance between the second sub-radiator (122) and the first sub-radiator (121) is smaller than a distance between the second sub-radiator (122) and the first antenna part (11).
 3. The dual band antenna as claimed in claim 1, **characterized in that** a total length of the first sub-radiator (121) and the second sub-radiator (122) is smaller than the length of the second radiation unit (112).
 4. The dual band antenna as claimed in claim 1, **characterized in that** a frequency of the second resonant signal is at least twice of a frequency of the first resonant signal, the length of the first radiation unit (111) equal to one fourth of the wavelength of the second resonant signal, and the length of the second radiation unit (112) equal to one fourth of the wavelength of the first resonant signal.
 5. The dual band antenna as claimed in claim 1, **characterized in that** the second radiation unit (112) is in parallel with a first direction, the coupling segment (121 a) is in parallel with a second direction, and the first direction and the second direction are perpendicular to each other.
 6. The dual band antenna as claimed in claim 5, **characterized in that** the first angle is an acute angle, and the second angle is a right angle or an obtuse angle.
 7. The dual band antenna as claimed in claim 5, wherein the first radiation unit (111) comprises:
 - an inclined segment (211 a), wherein the first angle is formed between the second radiation unit (112) and the inclined segment (211 a); and
 - a bent segment (211b), wherein a third angle is formed between the inclined segment (211 a) and the bent segment (211 b).
 8. The dual band antenna as claimed in claim 7, **characterized in that** the inclined segment (211a) is wider than the bent segment (211b), and the third angle is an obtuse angle.
 9. The dual band antenna as claimed in claim 1, **characterized in that** the second sub-radiator (122) is a strip-shaped sub-radiator and the length of the second sub-radiator (122) is shorter than or equal to a length of the coupling segment (121 a), or the second sub-radiator (122) is an inverted L-shaped sub-radiator comprising a long segment (722a) and a short segment (722b) and a length of the long segment (722a) is shorter than or equal to the length of the coupling segment (121 a).
 10. The dual band antenna as claimed in claim 9, **characterized in that** the long segment is in parallel with the coupling segment (121a), and the shortest distance between the short segment (722b) and the first antenna part (11) is shorter than or equal to the shortest distance between the long segment (722a) and the first antenna part (11).
 11. The dual band antenna as claimed in claim 1, **characterized in that** a first current flows through the second radiation unit (112) and a second current flows through the first sub-radiator (121) and the second sub-radiator (122) when the first resonant signal is fed into the dual band antenna, and a third current flows through the first radiation unit (111) and a fourth current flows through the second sub-radiator (122) and a portion of the first sub-radiator (121) when the second resonant signal is fed into the dual band antenna.
 12. The dual band antenna as claimed in claim 11, further comprising:
 - a first feeding point (15a) arranged between the first radiation unit (111) and the second radiation unit (112), wherein the first current and the third current flow through the first feeding point (15a); and
 - a second feeding point (15b) located at an end of the second sub-radiator (122), wherein the second current and the fourth current flow through the second feeding point (15b).
 13. The dual band antenna as claimed in claim 1, **characterized in that** the extension segment (121 b) is a meandering segment with plural sub-segments (6222a, 6222c and 6222d), and a turning angle is formed between any two adjacent sub-segments (6222a, 6222c and 6222d).

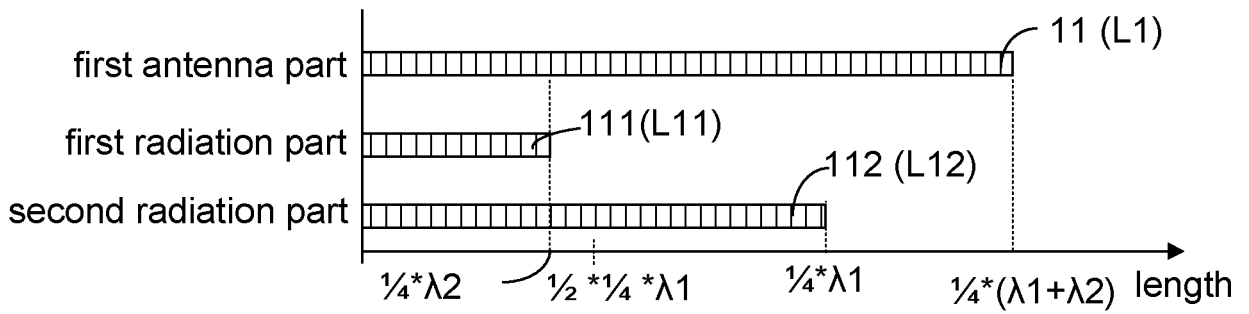


FIG. 2

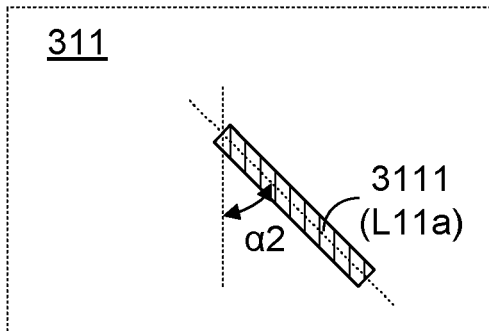


FIG. 3A

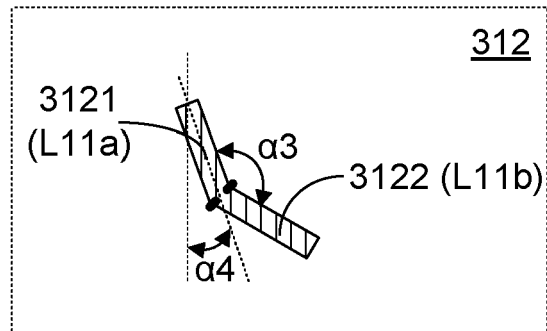


FIG. 3B

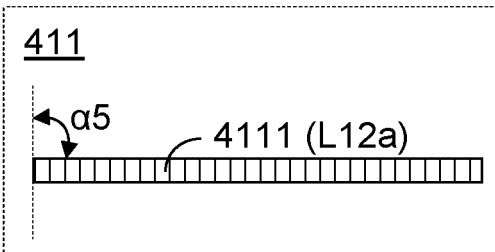


FIG. 4A

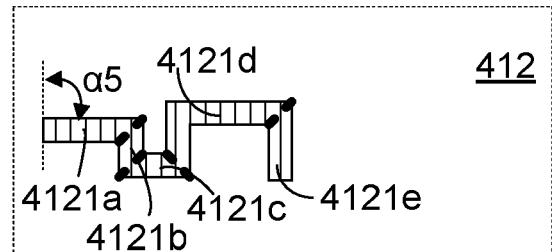


FIG. 4B

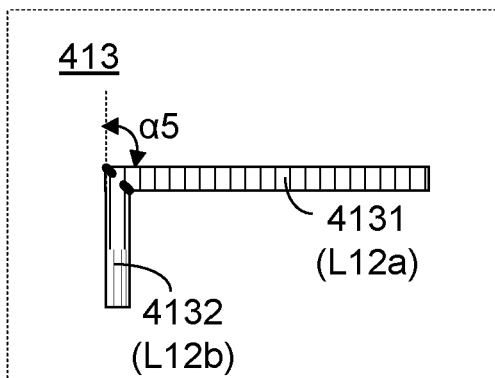


FIG. 4C

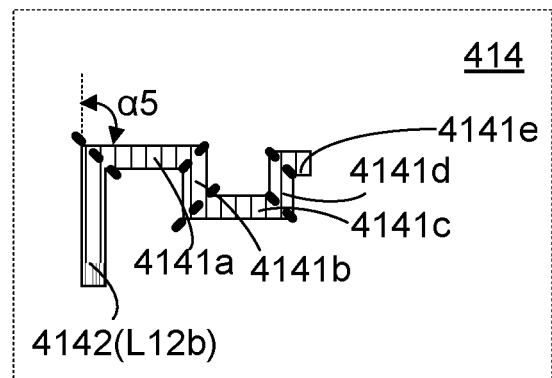


FIG. 4D

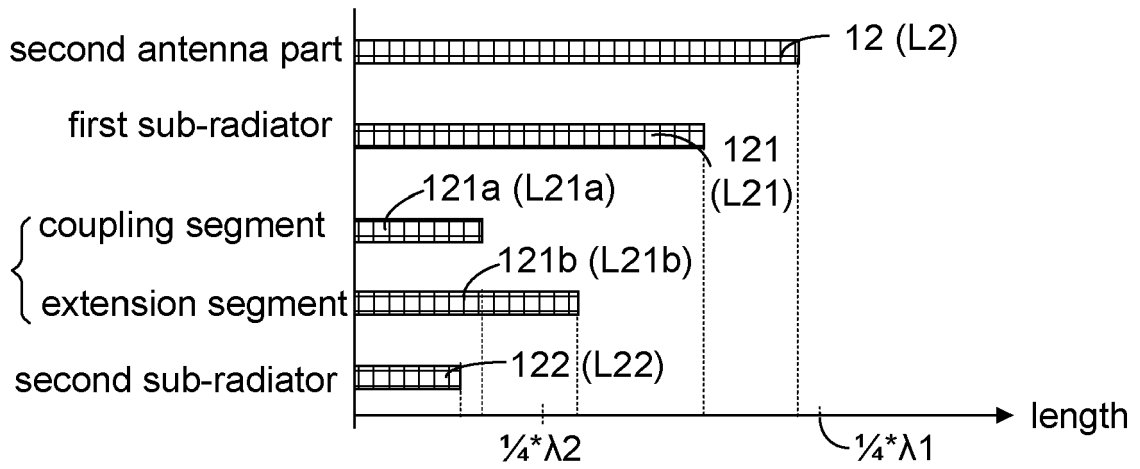


FIG. 5

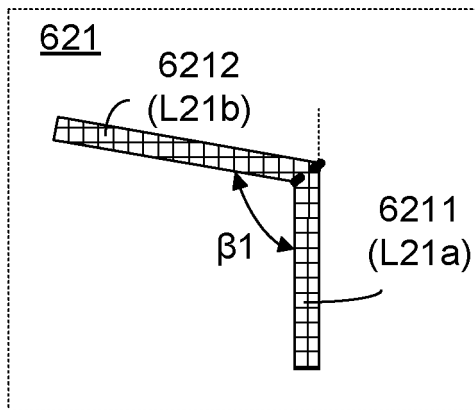


FIG. 6A

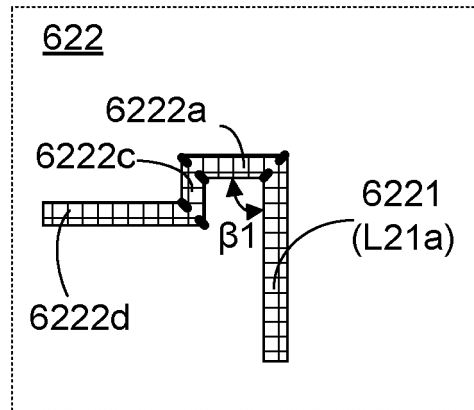


FIG. 6B

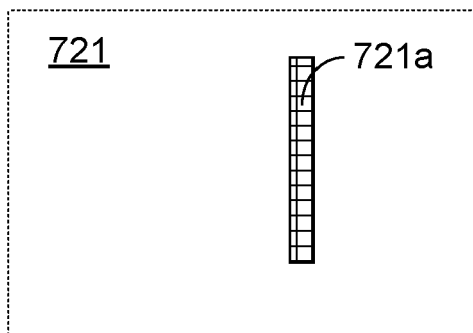


FIG. 7A

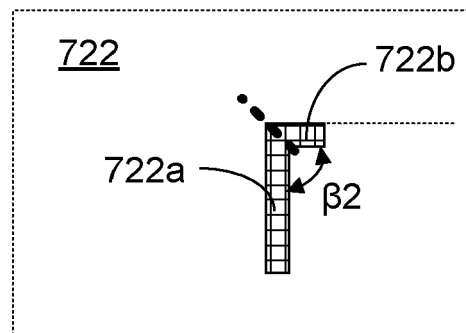


FIG. 7B

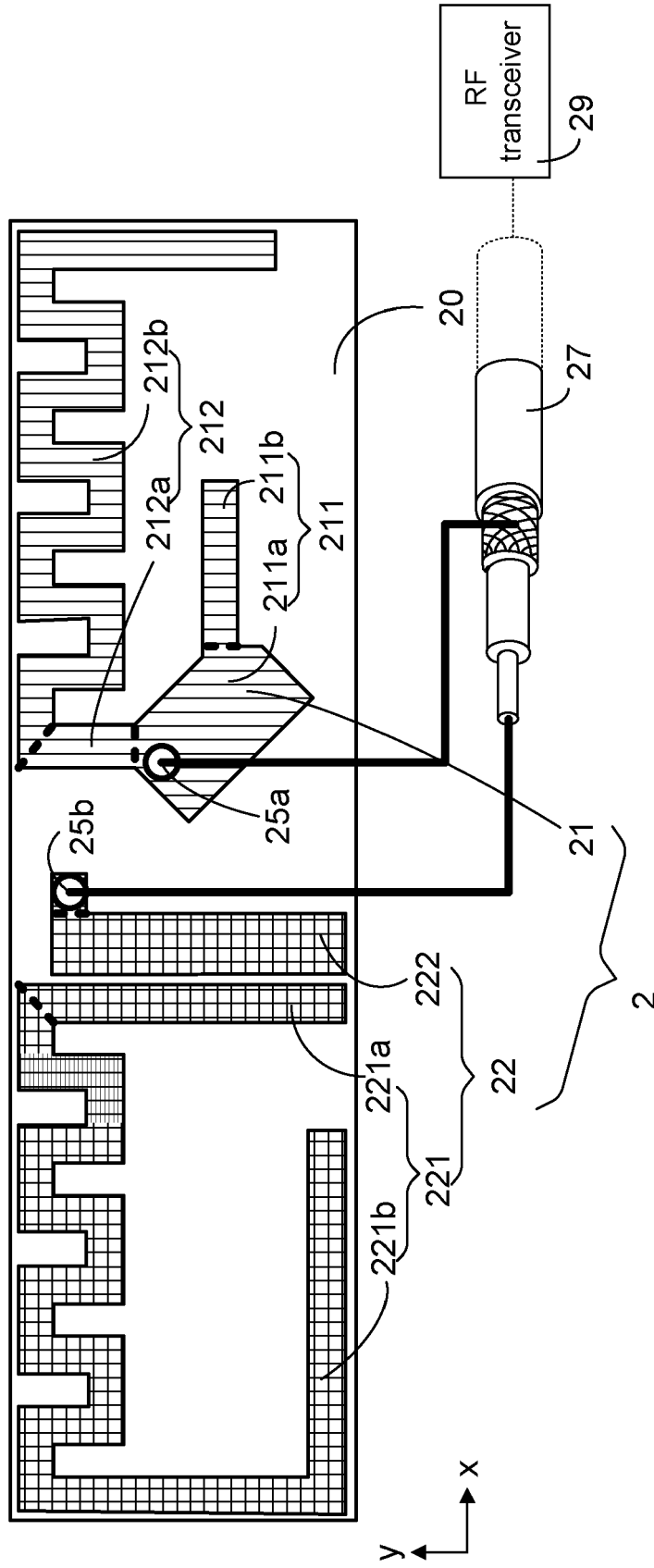


FIG. 8

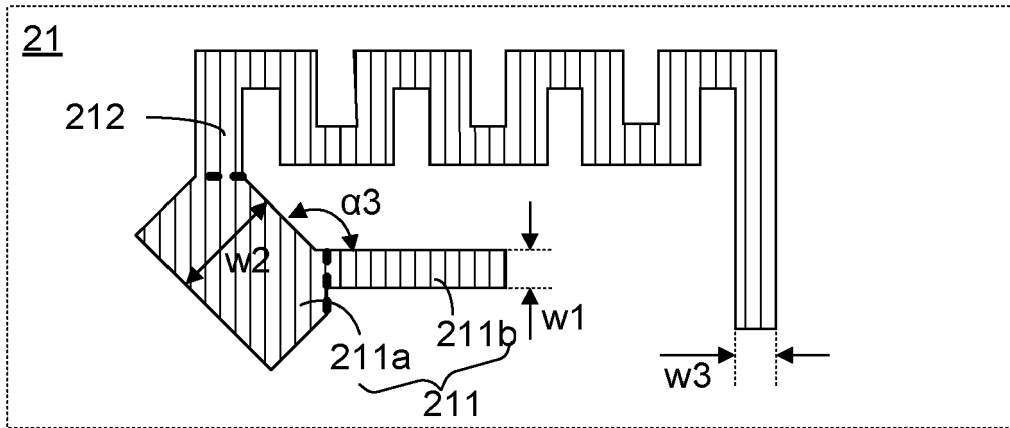


FIG. 9A

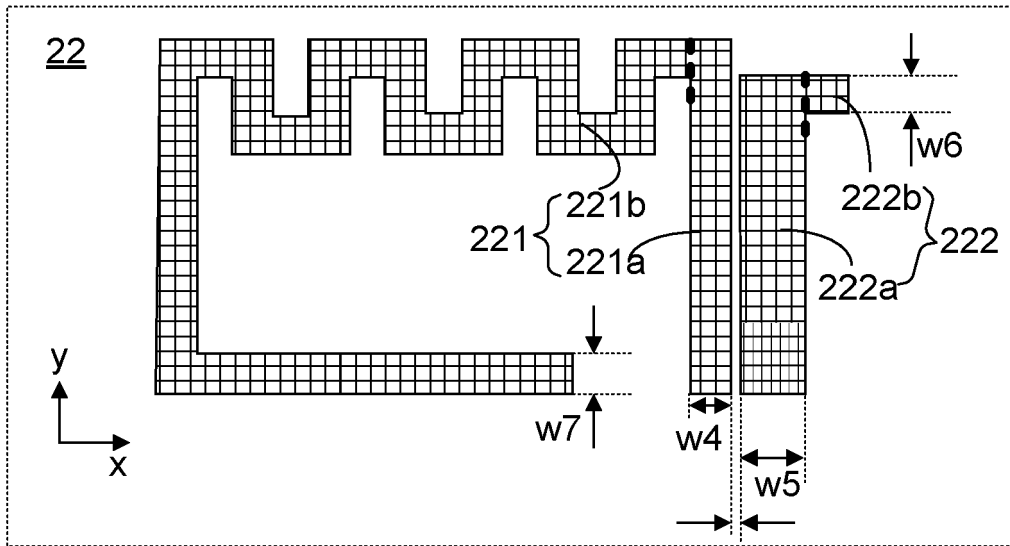


FIG. 9B

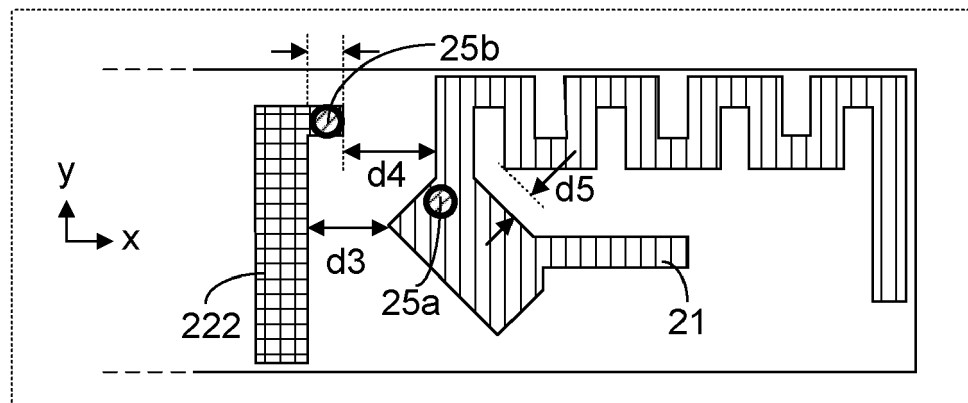


FIG. 9C

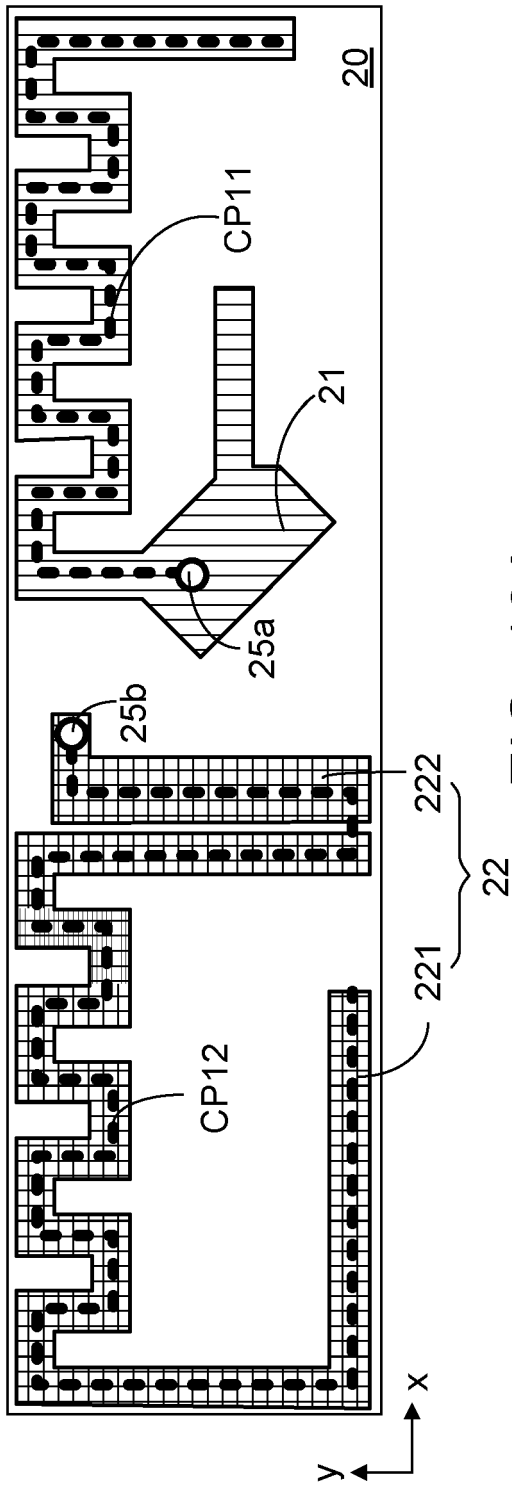


FIG. 10A

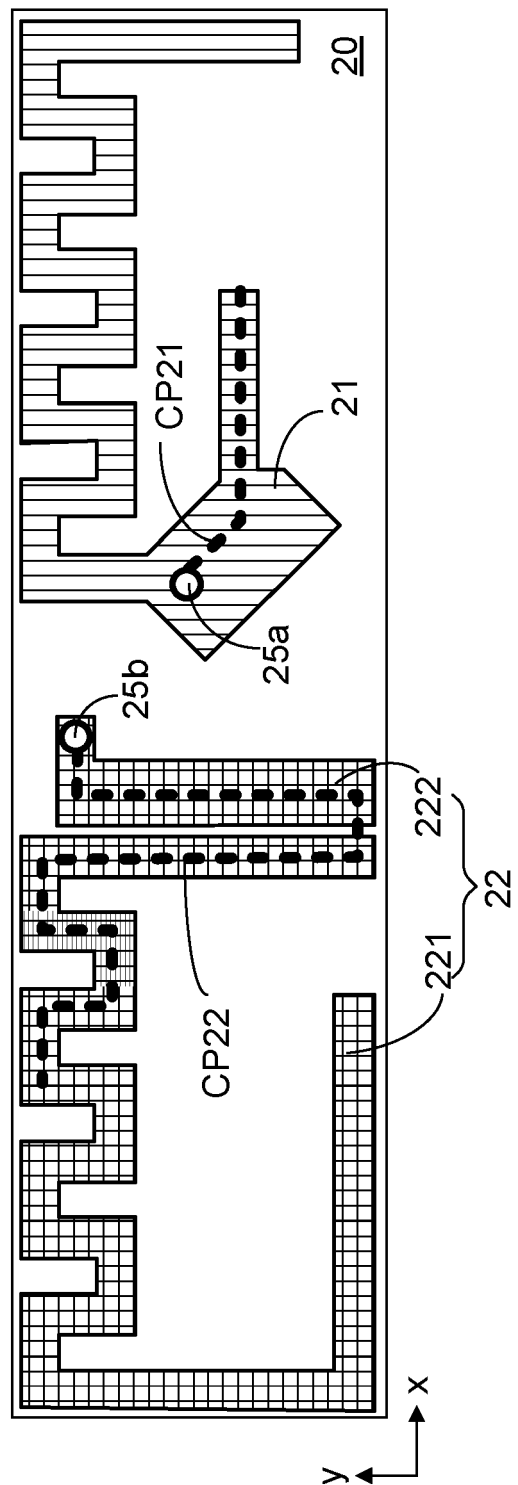


FIG. 10B



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Application Number
EP 17 17 6133

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Place of search The Hague		Date of completion of the search 24 October 2017	Examiner Mitchell-Thomas, R
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82