

(43) International Publication Date
12 May 2011 (12.05.2011)(10) International Publication Number
WO 2011/055159 A1

(51) International Patent Classification:

H01Q 1/24 (2006.01) *H01Q* 5/01 (2006.01)
H01Q 5/00 (2006.01)

(21) International Application Number:

PCT/IB2009/007318

(22) International Filing Date:

4 November 2009 (04.11.2009)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant (for all designated States except US): **LAIRD TECHNOLOGIES AB** [SE/SE]; Isafordsgatan 5, Kista 16440 (SE).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **KAIKKONEN, Andrei** [SE/SE]; Basunvägen 3, S-175 48 Järfälla (SE). **LINDBERG, Peter** [SE/SE]; Norrlandsgatan 44B, S-752 29 Uppsala (SE). **VON ARBIN, Axel Magnus** [SE/SE]; Bryggvagen 7, S-18363 Taby (SE). **TROSSING, Martin Evert** [SE/SE]; Strakvägen 2, S-18732 Taby (SE).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: MULTI-FREQUENCY ANTENNA ASSEMBLIES WITH MULTIPLE ANTENNAS

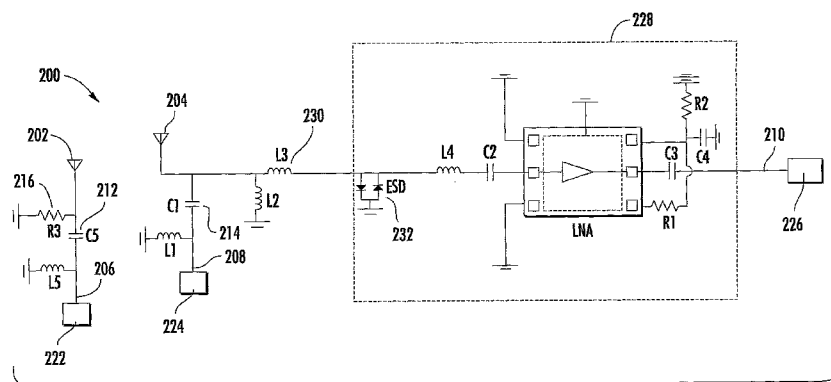


FIG. 2

(57) Abstract: Multi-frequency antenna assemblies including multiple antennas are disclosed. One example of an antenna assembly includes first and second antennas. The first antenna is configured to be resonant in a first frequency range. The second antenna is configured to be resonant in a second frequency range and a third frequency range. The first antenna is coupled to a first output. The second antenna is coupled to a second output and a third output. The second antenna is located near the first antenna. A first filter is coupled to the first antenna and the first output. A second filter is coupled to the second antenna and the second output. The first filter and the second filter are configured to reflect signals in the third frequency range.

MULTI-FREQUENCY ANTENNA ASSEMBLIES WITH MULTIPLE ANTENNAS

FIELD

[0001] The present disclosure relates to multi-frequency antenna assemblies with multiple antennas.

BACKGROUND

[0002] This section provides background information related to the present disclosure which is not necessarily prior art.

[0003] Wireless application devices, such as laptop computers, cellular phones, etc. are commonly used in wireless operations. Multiple various capabilities, such as, for example, voice/data communication (using one or more wireless protocols and/or frequency ranges), global positioning system (GPS) tracking, FM broadcast radio, short range wireless communications (e.g. Bluetooth, Wi-Fi, etc.), are often incorporated in wireless application devices. Antennas and antenna assemblies capable of handling the additional different frequency bands are desired.

SUMMARY

[0004] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0005] According to various aspects, example embodiments are provided of antenna assemblies configured to be installed to wireless application devices. In one example embodiment, an antenna assembly includes first and second antennas. The first antenna is configured to be resonant in a first frequency range. The first antenna is coupled to a first output. The second antenna is configured to be resonant in a second frequency range and a third frequency range. The second antenna is located near the first antenna. The second antenna is coupled to a second output and a third output. A first filter is coupled to the first antenna and the first output. A second filter is coupled to the second antenna and the second output. The first filter and the second filter are configured to reflect signals in the third frequency range.

[0006] In another example embodiment, an antenna assembly includes a ground plane and a first monopole antenna. The first monopole antenna is resonant in a frequency range about 2.45 gigahertz (GHz) and is coupled to a first output. A second monopole antenna is near and substantially parallel to the first monopole antenna. The second monopole antenna is resonant in a frequency range about 1.575 GHz and resonant in a FM broadcast band frequency range. The second monopole antenna is coupled to a second output and a third output. A first filter is coupled between the first monopole antenna and the first output. A second filter is coupled between the second monopole antenna and the second output. The first and second filters are each configured to reflect a signal in the FM broadcast frequency range.

[0007] In another example embodiment, an antenna assembly includes first and second antennas. The first antenna is configured to be resonant in a first frequency range. The first antenna is coupled to a first output. The second antenna is configured to be resonant in a second frequency range and a third frequency range. The second antenna is located near the first antenna. The second antenna is coupled to a second output and a third output. A first filter is coupled to the first antenna and the first output. The first antenna is grounded to signals in the third frequency range. The first filter is adapted to isolate the first antenna from ground for signals in the third frequency range.

[0008] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0009] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0010] FIG. 1 is a circuit diagram of an example embodiment of an antenna assembly including one or more aspects of the present disclosure;

[0011] FIG. 2 is a circuit diagram of another example embodiment of an antenna assembly including one or more aspects of the present disclosure;

[0012] FIG. 3 is an illustration of an exemplary prototype of an antenna assembly according to another example embodiment including one or more aspects of the present disclosure;

[0013] FIG. 4 is a Smith chart illustrating test results for the prototype antenna assembly of FIG. 3 over a frequency bandwidth of about 500 megahertz to about 3 gigahertz;

[0014] FIG. 5 is a line graph illustrating the return loss and isolation (in decibels) for the prototype antenna assembly of FIG. 3 over a frequency bandwidth of about 500 megahertz to about 3 gigahertz;

[0015] FIG. 6 is a line graph illustrating the efficiency (in decibels) for the prototype antenna assembly of FIG. 3 over a frequency bandwidth of about 1500 megahertz to about 1580 megahertz and from about 2400 megahertz to about 2480 megahertz;

[0016] FIG. 7 is a line graph illustrating antenna gain (in decibels) for the second antenna of the prototype antenna assembly of FIG. 3 over a frequency bandwidth of about 76 megahertz to about 108 megahertz; and

[0017] FIG. 8 is a line graph illustrating effective antenna efficiency (in decibels) for the second antenna of the prototype antenna assembly of FIG. 3 over a frequency bandwidth of about 76 megahertz to about 108 megahertz.

[0018] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

[0019] Example embodiments will now be described more fully with reference to the accompanying drawings.

[0020] Example embodiments are provided so that this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure. It will be apparent to those skilled in

the art that specific details need not be employed, that example embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the disclosure. In some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail.

[0021] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a", "an" and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises," "comprising," "including," and "having," are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

[0022] When an element or layer is referred to as being "on", "engaged to", "connected to" or "coupled to" another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly engaged to", "directly connected to" or "directly coupled to" another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.). As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0023] Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or

section. Terms such as “first,” “second,” and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

[0024] Disclosure of values and ranges of values for specific parameters (such as temperatures, molecular weights, weight percentages, etc.) are not exclusive of other values and ranges of values useful herein. It is envisioned that two or more specific exemplified values for a given parameter may define endpoints for a range of values that may be claimed for the parameter. For example, if Parameter X is exemplified herein to have value A and also exemplified to have value Z, it is envisioned that parameter X may have a range of values from about A to about Z. Similarly, it is envisioned that disclosure of two or more ranges of values for a parameter (whether such ranges are nested, overlapping or distinct) subsume all possible combination of ranges for the value that might be claimed using endpoints of the disclosed ranges. For example, if parameter X is exemplified herein to have values in the range of 1 – 10, or 2 – 9, or 3 – 8, it is also envisioned that Parameter X may have other ranges of values including 1 – 9, 1 – 8, 1 – 3, 1 - 2, 2 – 10, 2 – 8, 2 – 3, 3 – 10, and 3 – 9.

[0025] With reference now to the drawings, FIG. 1 illustrates an example embodiment of an antenna assembly 100 including one or more aspects of the present disclosure. The illustrated antenna assembly 100 may be integrated in, embedded in, installed to, etc. a wireless application device (not shown), including, for example, a personal computer, a cellular phone, personal digital assistant (PDA), etc. within the scope of the present disclosure.

[0026] As shown in FIG. 1, the assembly 100 includes a first antenna 102 and a second antenna 104. The first antenna 102 and the second antenna 104 are physically located near each other. The antennas 102, 104 may be any suitable antenna. In some embodiments, the antennas 102 and 104 are monopole antennas.

[0027] The first antenna 102 may be configured to be resonant in a first frequency range. The second antenna 104 may be configured to be

resonant in a second and a third frequency range. For example, the first antenna 102 may be a Bluetooth antenna configured for resonance in a frequency range about 2.45 gigahertz (GHz). The second antenna 104 may be a multi-frequency antenna configured for resonance in GPS (about 1.575 GHz) and FM broadcast (for example, 76 - 108.0 megahertz (MHz)) frequency ranges. Other frequency ranges, combinations of frequencies, and/or combinations of single frequency and multi-frequency antennas may be used with the antenna assembly 100.

[0028] The first antenna 102 is coupled to a first output 106 for transmission of signals to and/or from other circuitry (e.g., a transmitter, receiver, transceiver, etc.). Similarly, the second antenna 104 is coupled to a second output 108 and a third output 110 for transmission of signals to and/or from other circuitry.

[0029] A first filter 112 is coupled between the first antenna 102 and the first output 106. Because the first antenna 102 is physically close with the second antenna 104 (and thus may electromagnetically interact with the second antenna 104), possible grounding of third frequency range signals in the first antenna via the matching inductor L5 often decreases the performance of the second antenna 104 when receiving signals in the third frequency range. The first filter 112 is adapted to isolate the first antenna 102 from ground at frequencies in the third frequency range. The first filter 112 acts as a high pass filter to block and reflect signals in the third frequency range from the first output 106. Accordingly, signals in the third frequency range are blocked and reflected, rather than being directed to ground. This permits the first antenna 102 and the second antenna 104 to be placed in close physical relationship with each other without significantly degrading the performance of the second antenna 104 in the third frequency range.

[0030] A second filter 114 is coupled between the second antenna 104 and the second output 108. The second filter 114 is a high pass filter. The second filter 114 permits higher frequency signals, such as signals in the second frequency range (e.g., GPS signals, etc.), to pass between the second antenna 104 and the second output 108. Conversely, the second filter 114 blocks and reflects signals in the third frequency range (e.g., FM broadcast frequency signals, etc.), without directing such signals to ground via the

matching inductor L1. Accordingly, the second filter 114 contributes to preventing (or at least reducing) degradation in the performance of the second antenna 104 with signals in the third frequency range.

[0031] The first filter 112 and the second filter 114 may be any suitable filter operable in the manner discussed above. In some example embodiments disclosed herein, the first and second filters 112, 114 are capacitors. Either or both of the first and/or second filters 112, 114 may also be series resonant circuits (an inductor and a capacitor). If either or both of the filters 112, 114 are series resonant circuits, the filter may be configured (through, for example, selection of appropriate capacitor(s) and inductor(s)) as a band pass filter. In such embodiments, the filters 112, 114 block and reflect signals at frequencies both above and below a frequency range. For example, the second filter 114 may block signals above and below the second frequency range, while allowing signals in the second frequency range to be transmitted between the second antenna 104 and the second output 108. Although described together above, the first filter 112 and the second filter 114 do not have to be identical or even the same type of filter. For example, one filter may be a capacitor and the other filter may be a series resonant circuit.

[0032] The antenna assembly 100 includes a DC-electrostatic discharge (ESD) device 116 to provide a direct current (DC) path to ground to discharge electrostatic charges.

[0033] An inductor 118, or the inductor 118 and the first filter 112, forms a matching circuit for impedance matching of the first antenna 102. Similarly, an inductor 120, or the inductor 120 and the second filter 114, forms a matching circuit for impedance matching of the second antenna 104. Other appropriate matching circuits may be used without departing from the scope of this disclosure.

[0034] FIG. 2 illustrates another example embodiment of an antenna assembly 200 according to one or more aspects of this disclosure. The illustrated antenna assembly 200 may be integrated in, embedded in, installed to, etc. a wireless application device (not shown), including, for example, a personal computer, a cellular phone, personal digital assistant (PDA), etc. within the scope of the present disclosure.

[0035] As shown in FIG. 2, the assembly 200 includes a first antenna 202 and a second antenna 204. The first antenna 202 and the second antenna 204 are physically located near each other. The antennas 202, 204 may be any suitable antenna. In some embodiments, the antennas 202 and 204 are monopole antennas. The first antenna 202 is configured to be resonant in a first frequency range. The second antenna 204 is configured to be resonant in a second and a third frequency range.

[0036] The first antenna 202 is coupled to a first output 206 for transmission of signals to and/or from other circuitry 222, which may be, for example, a transmitter, receiver, transceiver, etc. Similarly, the second antenna 204 is coupled to a second output 208 and a third output 210 for transmission of signals to and/or from other circuitry 224 and 226, respectively. The circuitry 222, 224, 226 may be separate components, devices, circuits, etc. or may be part of the same component, device circuit, etc.

[0037] Because the first antenna 202 is physically close to the second antenna 204 (and thus may electromagnetically interact with the second antenna 204), possible grounding of third frequency range signals in the first antenna 202 via the matching inductor L5 often decreases the performance of the second antenna 204 when receiving signals in the third frequency range. The first filter 212 is adapted to isolate the first antenna 202 from ground at frequencies in the third frequency range. The first filter 212 acts as a high pass filter to block and reflect signals in the third frequency range from the first output. Accordingly, signals in the third frequency range are blocked and reflected, rather than being directed to ground. This permits the first antenna 202 and the second antenna 204 to be placed in close physical relationship with each other without significantly degrading the performance of the second antenna 204 in the third frequency range.

[0038] A second filter 214 is coupled between the second antenna 204 and the second output 208. The second filter 214 is a high pass filter. The second filter 214 permits higher frequency signals, such as signals in the second frequency range (e.g., GPS signals, etc.), to pass between the second antenna 204 and the second output 208. Conversely, the second filter 214 blocks and reflects signals in the third frequency range (e.g., FM broadcast

frequency signals, etc.), without directing such signals to ground via matching inductor L1. Accordingly, the second filter 214 contributes to preventing (at least reducing) degradation in the performance of the second antenna 204 with signals in the third frequency range.

[0039] The first filter 212 and the second filter 214 are capacitors in the particular embodiment of FIG. 2. As discussed above with respect to FIG.1, however, any suitable filter or combination of filters may be used, including, for example, series resonant circuits (e.g., an inductor and a capacitor).

[0040] The antenna assembly 200 includes a DC-electrostatic discharge (ESD) device 216 to provide a direct current (DC) path to ground to discharge electrostatic charges.

[0041] An amplifier 228 is coupled between the antenna 204 and the third output 210 to amplify signals in the third frequency range. A low pass filter 230 is coupled between the second antenna 204 and the third output 210. The low pass filter allows signals in the third frequency range (e.g., FM broadcast band signals, etc.) to pass, while blocking signals in higher frequency ranges (including the second and third frequency ranges). This helps prevent other signals from opening a path to ground through an ESD device 230 or saturating the amplifier 228.

[0042] FIG. 3 illustrates an example embodiment of the antenna assembly of FIG. 2. In the antenna assembly 300, the first antenna 202 and the second antenna 204 are separated by about one millimeter. By way of example only, the first antenna 202 may have a length of about 25 millimeters, and the second antenna 204 may have a length of about 40 millimeters. In this particular example, the antenna assembly 300 may have a thickness of about 5 millimeters. Alternative embodiments may include one or more components configured differently and in different sizes. The dimensions provided in this paragraph (as are all dimensions disclosed herein) are for purposes of illustration only and not for purposes of limitation.

[0043] The first and second antennas 202, 204 are suspended above a ground plane 232 by carrier 234. The carrier 234 may be plastic or any other suitable nonconductive material. In the assembly 300, the first antenna 202 is a Bluetooth antenna configured for resonance in a frequency

range about 2.45 gigahertz (GHz). The second antenna 204 is a multi-frequency antenna configured for resonance in GPS (about 1.575 GHz) and FM broadcast (for example, 76 - 108.0 megahertz (MHz)) frequency ranges. Other frequency ranges, combinations of frequencies and/or combinations of single frequency and multi-frequency antennas may be used with the antenna assembly 200.

[0044] In the assembly 200 shown in FIG. 2, the DC-ESD discharge device 216 may comprise a resistor R3 having a resistance of 560 kilo ohms (kOhms), and the inductors L5 and L1 may comprise 3.3 nanoHenry (nH) inductors. The first filter 212 (C5) and the second filter 214 (C1) may be 1 picoFarad (pF) capacitors, and the low pass filter 230 (L3) may be a 56nH inductor. Continuing with this example, capacitors C2 and C3 may be 330 pF capacitors, and capacitor C4 may be a 10 nF capacitor. Inductors L2 and L4 may be 470 nH and 91 nH inductors, respectively. Resistors R1 and R2 may be 10 KOhm and 0 Ohm resistors, respectively. Alternative embodiments may include one or more components configured differently and in different sizes. The numerical values provided in this paragraph (as are all numerical values disclosed herein) are for purposes of illustration only and not for purposes of limitation.

[0045] FIGS. 4 through 8 illustrate various test results obtained by testing of the prototype antenna assembly 300 shown in FIG. 3. These test results shown in FIGS. 4 through 8 are provided only for purposes of illustration and not for purposes of limitation.

[0046] FIG. 4 is a Smith chart illustrating performance of the first antenna 202 represented by line 436 and performance of the second antenna 204 represented by line 438 from a frequency of about 500 MHz to about 3 GHz. Generally, FIG. 4 shows that both antennas illustrate single-resonant optimal overcoupling.

[0047] FIG. 5 is a graph of the return loss and isolation (in decibels (dB)) of the first and second antennas 202, 204 from about 500 MHz to about 3 GHz. Trace 540 shows the return loss for the second antenna 204, while trace 542 illustrates return loss for the first antenna 202. As can be seen, the second antenna 204 has a bandwidth of about 60 MHz (measured at -6 dB) and the first antenna 202 has a bandwidth of about 110 MHz (also measured

at -6 dB). The isolation, which is greater than 12 dB, for the first and second antenna 202, 204 is shown at 544.

[0048] FIG. 6 graphically represents the efficiency (in dB) of the first antenna 202 from about 1550 MHz to about 1580 MHz and the efficiency of second antenna 204 from about 2400 MHz to about 2480 MHz.

[0049] FIG. 7 graphically illustrates the gain (in dB) of the second antenna 204 from about 76 MHz to about 108 MHz (the FM broadcast band). The average gain over the FM broadcast band is about -14.4 dB.

[0050] FIG. 8 graphically represents the effective antenna efficiency (in dB) of the second antenna 204 from about 76 MHz to about 108 MHz. The effective antenna efficiency is the signal to noise ratio of an antenna compared to an ideal loss-less dipole with all antennas connected to a receiver. Trace 846 is the effective antenna efficiency with a 0dB noise figure in the receiver. Trace 848 is the effective antenna efficiency with a 6dB noise figure in the receiver. As can be seen, the effective antenna efficiency with a 0dB noise figure is about -32.7dB and the effective antenna efficiency with a 6dB noise figure is about -27.1dB.

[0051] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the invention, and all such modifications are intended to be included within the scope of the invention.

CLAIMS

What is claimed is:

1. An antenna assembly comprising:
 - a first antenna configured to be resonant in a first frequency range, the first antenna coupled to a first output;
 - a second antenna configured to be resonant in a second frequency range and a third frequency range, the second antenna located near the first antenna, the second antenna coupled to a second output and a third output;
 - a first filter coupled to the first antenna and the first output; and
 - a second filter coupled to the second antenna and the second output;
 - the first filter and the second filter configured to reflect signals in the third frequency range.
2. The antenna assembly of claim 1, wherein the first antenna and the second antenna are monopole antennas.
3. The antenna assembly of claim 1 or 2, further comprising a DC-electrostatic discharge device coupled between the first antenna and a ground terminal.
4. The antenna assembly of any one of claims 1, 2, or 3, wherein at least one of the first and second filters is a capacitor.
5. The antenna assembly of any one of claims 1, 2, 3, or 4, wherein at least one of the first and second filters is a series resonant circuit.
6. The antenna assembly of any one of claims 1, 2, 3, 4, or 5, wherein:
 - the first frequency range is centered about 2.45 gigahertz;
 - the second frequency range is centered about 1.575 gigahertz; and
 - the third frequency range is about 76 megahertz to about 108 megahertz.
7. The antenna assembly of any one of claims 1, 2, 3, 4, 5, or 6, wherein the first and second antennas are spaced apart about one millimeter.
8. The antenna assembly of any one of claims 1, 2, 3, 4, 5, 6, or 7, wherein the first frequency range is a Bluetooth frequency range, the second frequency range is a GPS frequency range, and the third frequency range is an FM broadcast band frequency range.

9. The antenna assembly of any one of claims 1, 2, 3, 4, 6, or 7, wherein:

the first antenna is a Bluetooth monopole antenna; and
the second antenna is a GPS and FM monopole antenna.

10. An antenna assembly comprising:
a ground plane;
a first monopole antenna resonant in a frequency range centered about 2.45 gigahertz (GHz) coupled to a first output;

a second monopole antenna resonant in a frequency range centered about 1.575 GHz and resonant in a FM broadcast band frequency range, the second monopole antenna near and substantially parallel to the first monopole antenna, the second monopole antenna coupled to a second output and a third output;

a first filter coupled between the first monopole antenna and the first output; and

a second filter coupled between the second monopole antenna and the second output;

the first and second filter each configured to reflect a signal in the FM broadcast frequency range.

11. The antenna assembly of claim 10, further comprising a carrier on which the first and second monopole antennas are mounted.

12. The antenna assembly of claim 10 or 11, wherein a separation distance between parallel portions of the first monopole antenna and the second monopole antenna is about one millimeter.

13. The antenna assembly of any one of claims 10, 11, or 12, further comprising a DC-electrostatic discharge device coupled between the first monopole antenna and a ground terminal.

14. The antenna assembly of any one of claims 10, 11, 12, or 13, wherein at least one of the first and second filters is a capacitor.

15. The antenna assembly of any one of claims 10, 11, 12, 13, or 14, wherein at least one of the first and second filters is a series resonant circuit.

16. The antenna assembly of any one of claims 11, 11, 12, 13, 14, or 15, further comprising an amplifier coupled between the second monopole antenna and the third output.

17. The antenna assembly of claim 16, further comprising a low pass filter coupled between the second monopole antenna and the amplifier.

18. The antenna assembly of any one of claims 10, 11, 12, 13, 14, 15, or 16, wherein the FM broadcast band frequency range is about 76 megahertz to about 108 megahertz.

19. An antenna assembly comprising:
a first antenna configured to be resonant in a first frequency range, the first antenna coupled to a first output;

a second antenna configured to be resonant in a second frequency range and a third frequency range, the second antenna located near the first antenna, the second antenna coupled to a second output and a third output;
and

a first filter coupled to the first antenna and the first output,
wherein the first antenna is grounded to signals in the third frequency range and the first filter is configured to isolate the first antenna from ground for signals in the third frequency range.

20. The antenna assembly of claim 19, further comprising a second filter coupled between the second antenna and the second output, the second filter adapted to reflect a signal in the third frequency range.

21. The antenna assembly of claim 19 or 20, further comprising a DC-electrostatic discharge device coupled between the first antenna and a ground terminal.

22. The antenna assembly of any of claims 19, 20, or 21, wherein at least one of the first and second filters is a capacitor.

23. The antenna assembly of any of claims 19, 20, 21, or 22, wherein at least one of the first and second filters is a series resonant circuit.

24. The antenna assembly of any one of claims 19, 20, 21, 22, or 23, wherein:

the first frequency range is centered about 2.45 gigahertz;

the second frequency range is centered about 1.575 gigahertz; and

the third frequency range is about 76 megahertz to about 108 megahertz.

25. The antenna assembly of any one of claims 19, 20, 21, 22, 23, or 24, wherein the first and second antennas are spaced apart about one millimeter.

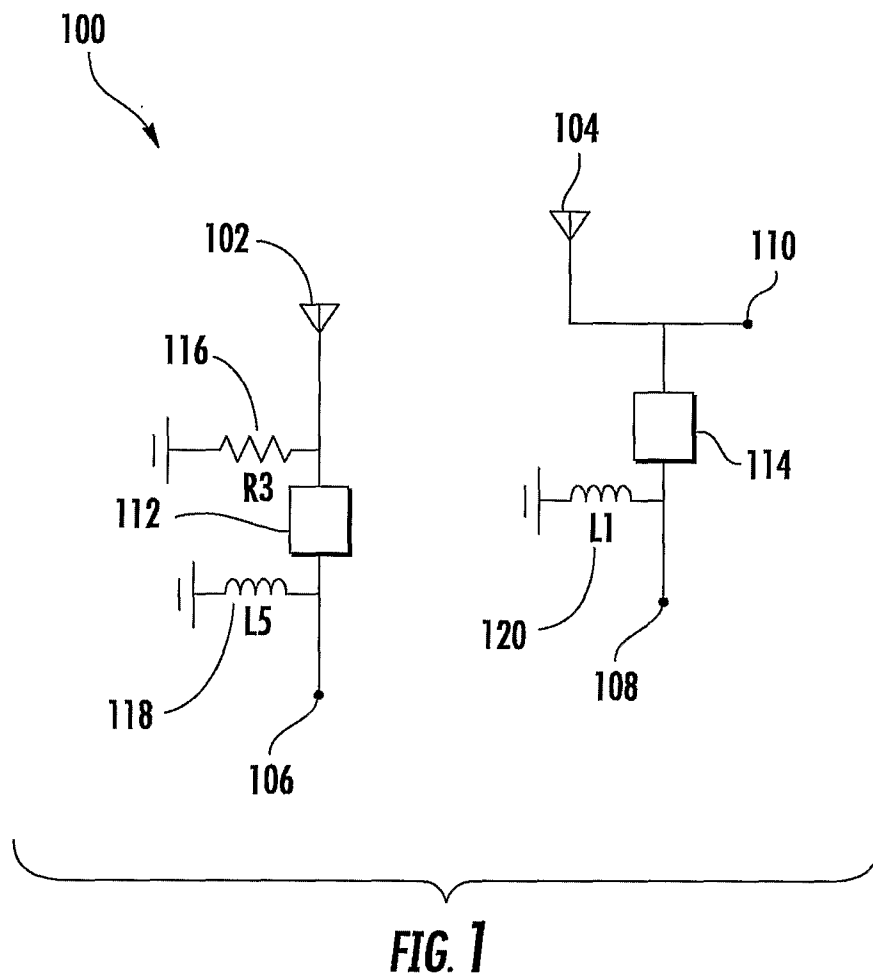
26. The antenna assembly of any one of claims 19, 20, 21, 22, 23, 24, or 25, wherein the first frequency range is a Bluetooth frequency range, the second frequency range is a GPS frequency range, and the third frequency range is an FM broadcast band frequency range.

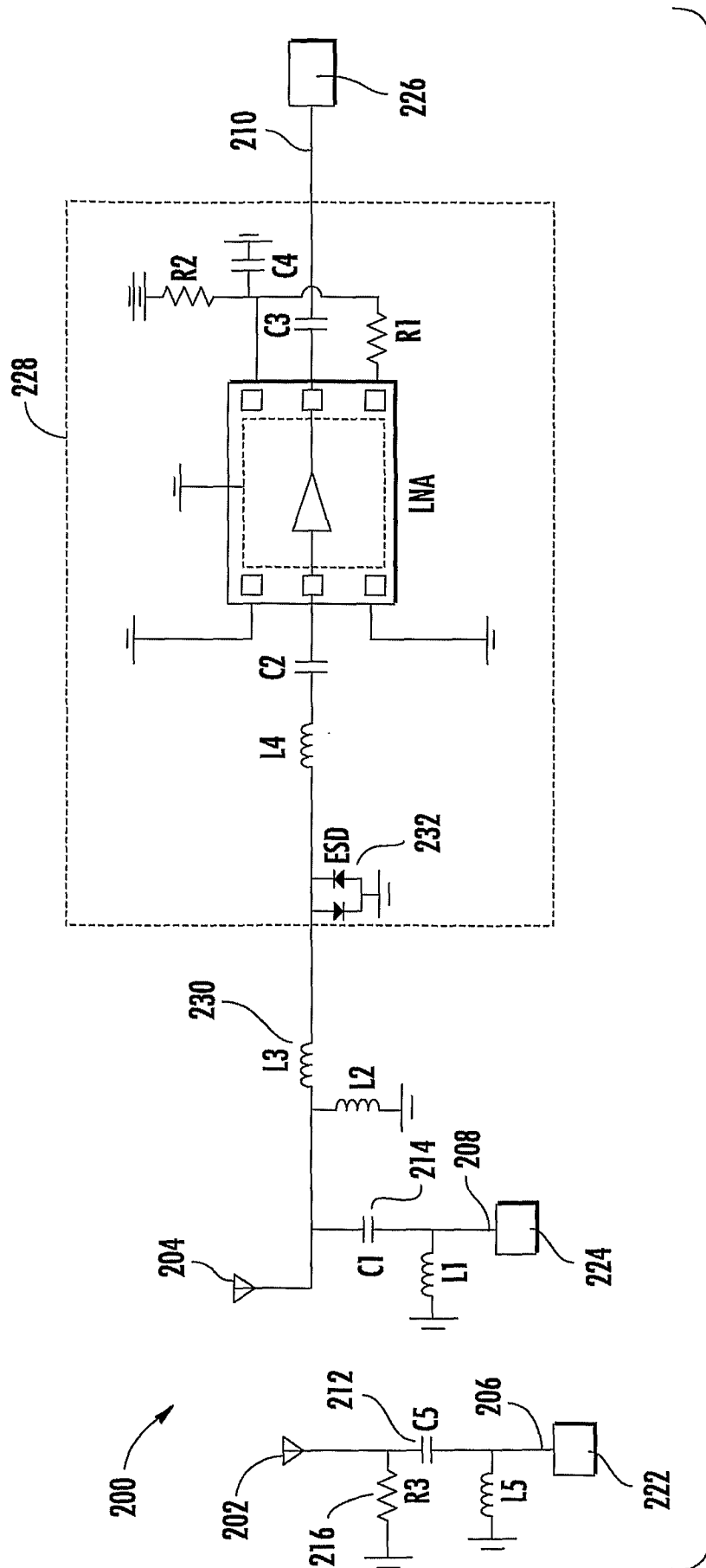
27. The antenna assembly of any one of claims 19, 20, 21, 22, 23, 24, 25, or 26, wherein:

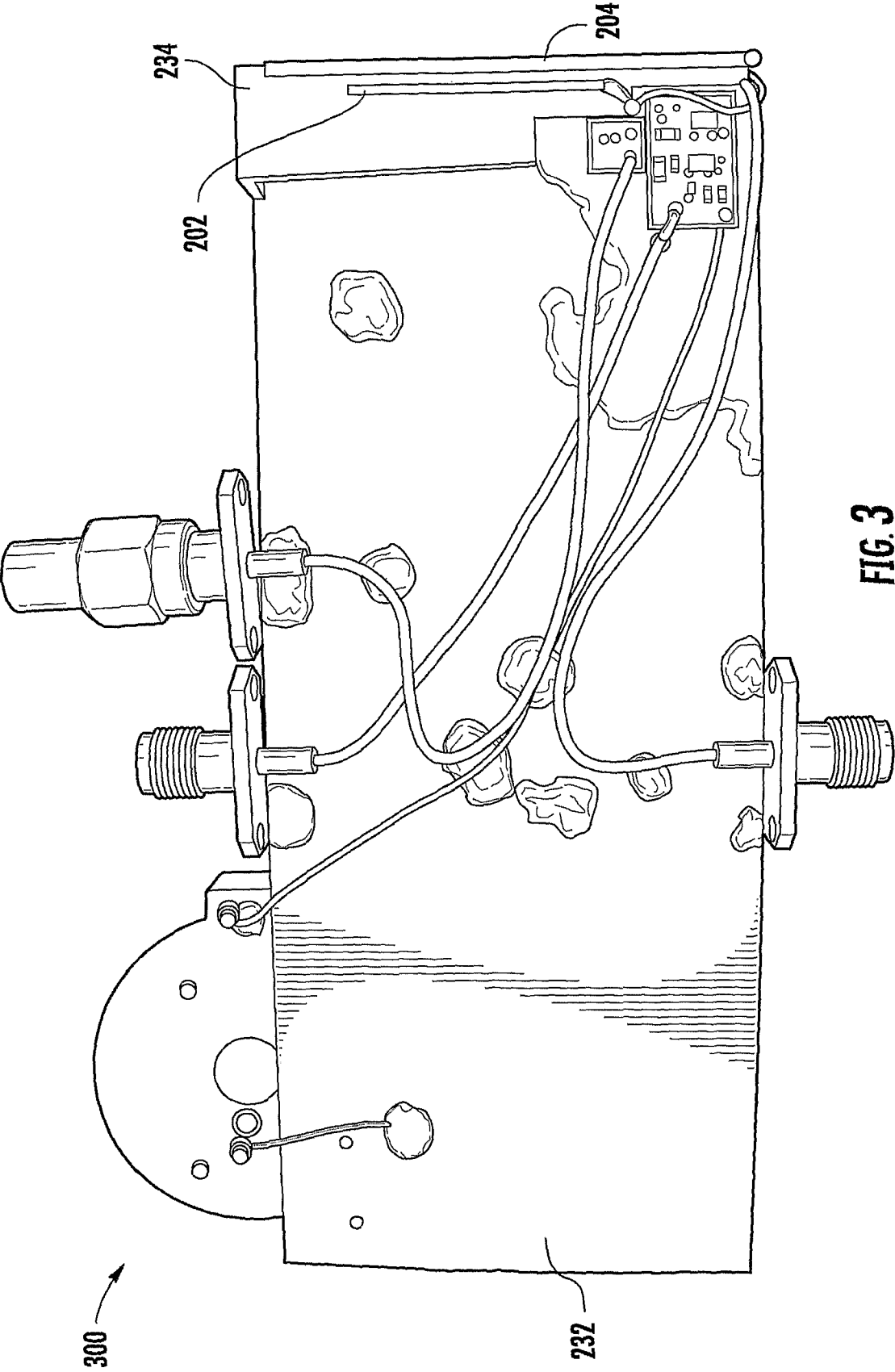
the first antenna is a Bluetooth monopole antenna; and

the second antenna is a GPS and FM monopole antenna.

28. A wireless application device including the antenna assembly of any one of the preceding claims.







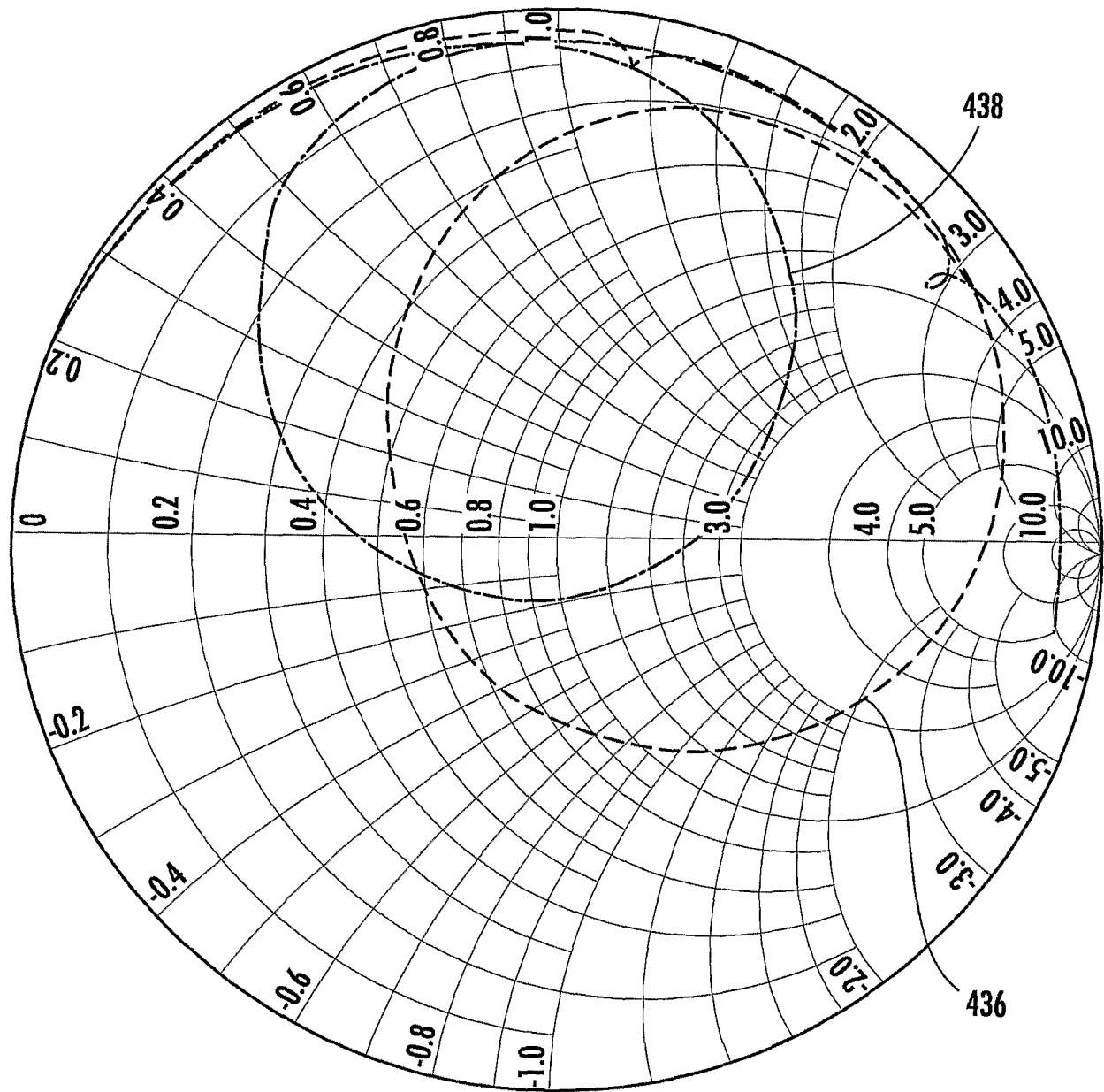
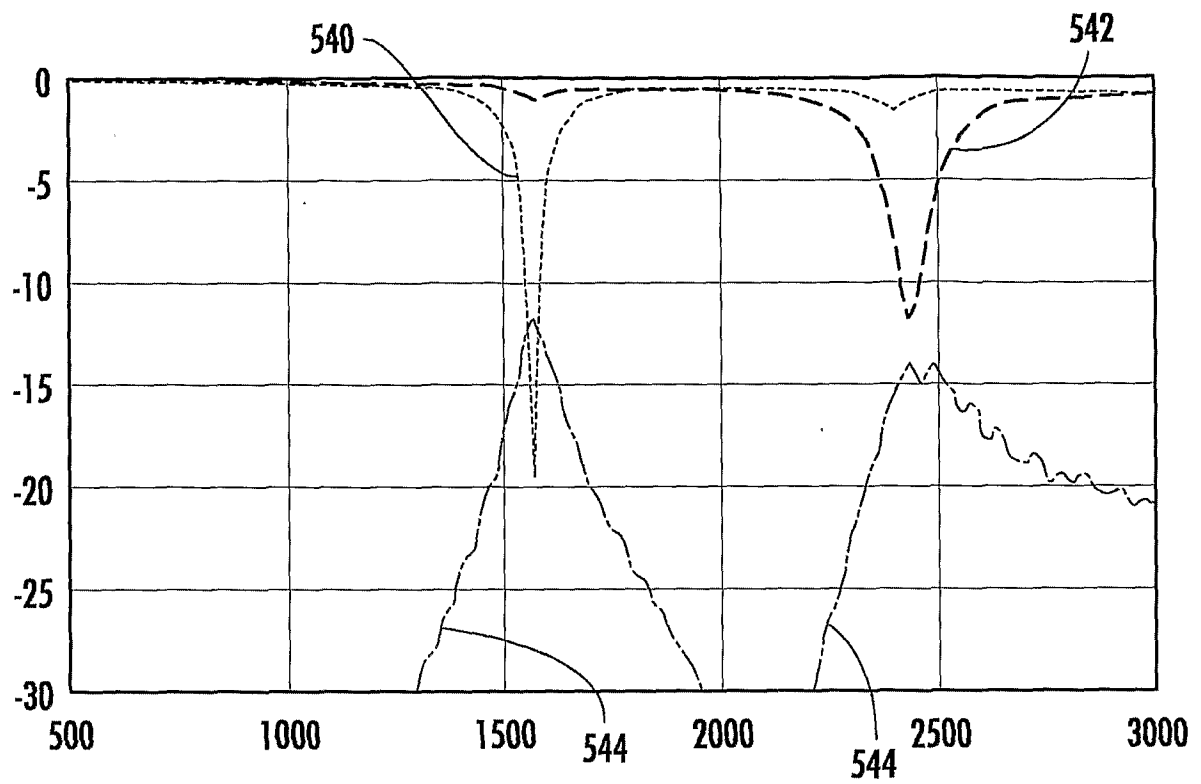
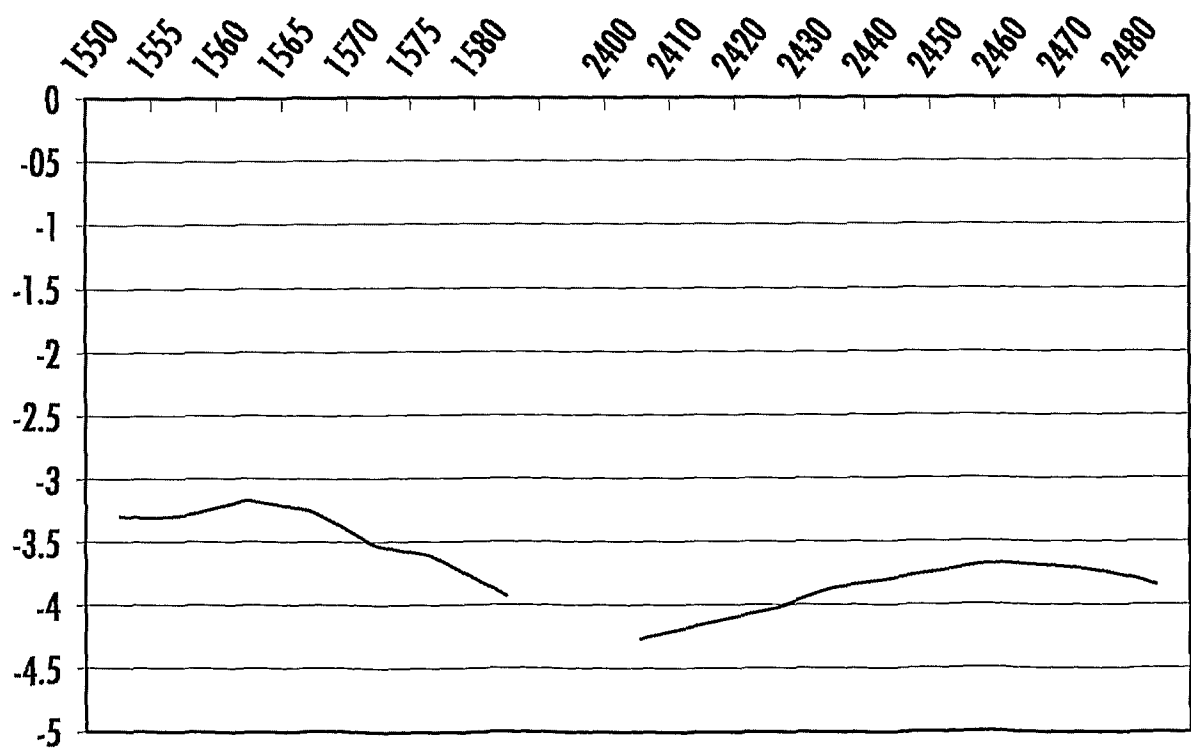
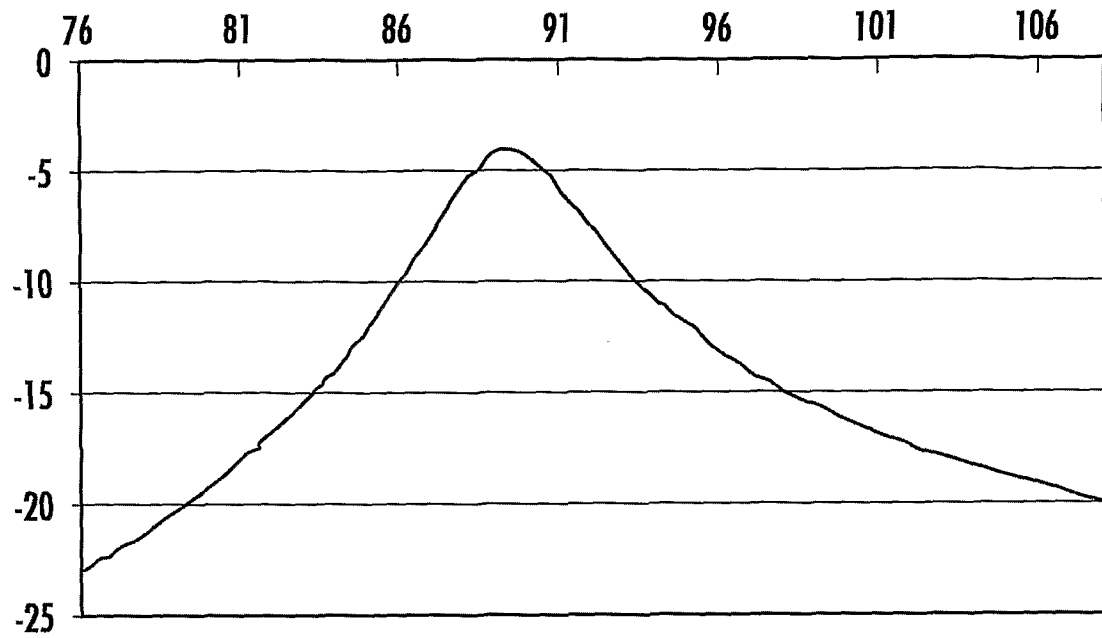
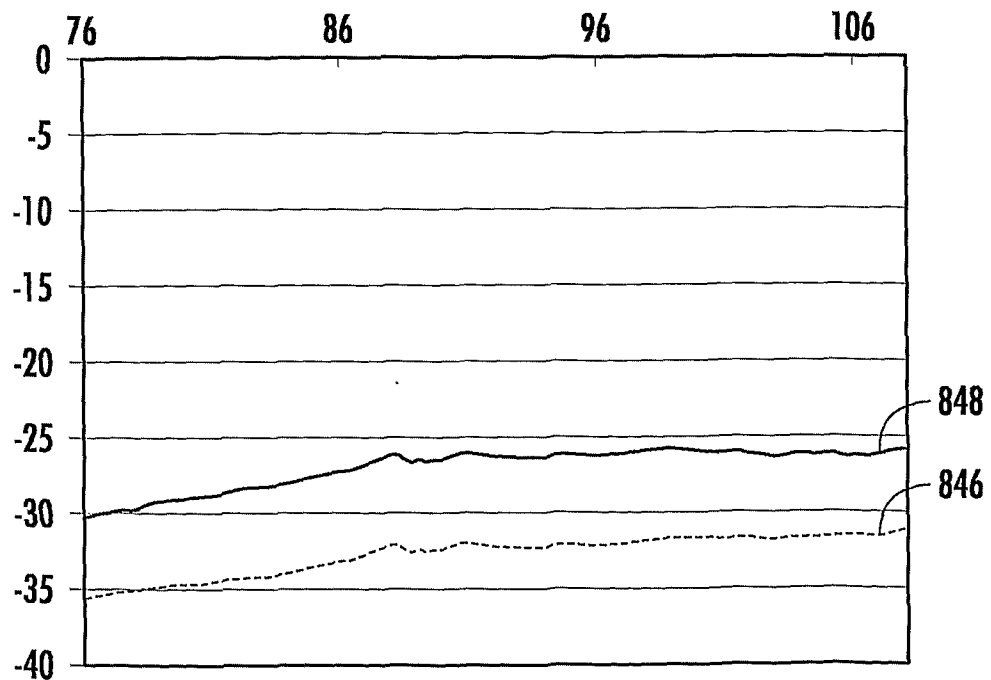


FIG. 4

**FIG. 5****FIG. 6**

**FIG. 7****FIG. 8**

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2009/007318

A. CLASSIFICATION OF SUBJECT MATTER

INV. H01Q1/24 H01Q5/00 H01Q5/01
 ADD.

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)

H01Q

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 2 065 969 A1 (LAIRD TECHNOLOGIES AB [SE]) 3 June 2009 (2009-06-03) abstract; figures 1,2 paragraphs [0011], [0 19] - [0025]	1-28
Y	EP 1 378 959 A1 (UBE INDUSTRIES [JP]; YOKOWO SEISAKUSHO KK [JP]) 7 January 2004 (2004-01-07) abstract; figures 1,5-7,15 paragraphs [0022] - [0026], [0047]	1-28
A	US 2007/139282 A1 (HARUYAMA SHINICHI [JP]) 21 June 2007 (2007-06-21) abstract; figures 8-11 paragraph [0035] - paragraph [0052]	1-28
	----- -/--	



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 document 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.

"8" document member of the same patent family

Date of the actual completion of the international search

10 May 2010

Date of mailing of the international search report

27/05/2010

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040,
 Fax: (+31-70) 340-3016

Authorized officer

Unterberger, Michael

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2009/007318

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2008/084557 A1 (MATSUSHITA ELECTRIC IND CO LTD [JP]; KOYANAGI YOSHIO; NAGANO KENYA) 17 July 2008 (2008-07-17) abstract; figures 1-5 -----	1-28
A	JP 2003 273687 A (HITACHI METALS LTD) 26 September 2003 (2003-09-26) abstract; figures 1-5 -----	1-28
A	EP 1 569 300 A1 (MATSUSHITA ELECTRIC IND CO LTD [JP] PANASONIC CORP [JP]) 31 August 2005 (2005-08-31) abstract; figure 1 paragraph [0014] - paragraph [0025] -----	1-28

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2009/007318

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 2065969	A1	03-06-2009	WO 2009070100 A1	04-06-2009
EP 1378959	A1	07-01-2004	CN 1500297 A	26-05-2004
			WO 02067372 A1	29-08-2002
			JP 3868775 B2	17-01-2007
			JP 2002325015 A	08-11-2002
			US 2004066337 A1	08-04-2004
US 2007139282	A1	21-06-2007	NONE	
WO 2008084557	A1	17-07-2008	EP 2117072 A1	11-11-2009
			US 2010053020 A1	04-03-2010
JP 2003273687	A	26-09-2003	JP 4224802 B2	18-02-2009
EP 1569300	A1	31-08-2005	CN 1661855 A	31-08-2005
			JP 4301034 B2	22-07-2009
			JP 2005244553 A	08-09-2005
			US 2005190107 A1	01-09-2005