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(54) **Multi-band antenna, and associated methodology, for a radio communication device**

Multiband-Antenne und entsprechendes Verfahren für ein Funkkommunikationsgerät

Antenne multibande et méthodologie associée pour dispositif de communication radio

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(56) References cited:
WO-A-02/35652
WO-A-2004/008573
US-A1- 2002 075 190
US-A1- 2003 142 022
US-A1- 2005 270 241

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Description

[0001] The present invention relates generally to a manner by which to transduce signal energy at a radio device, such as a portable mobile station. More particularly, the present invention relates to an antenna, and an associated methodology, for the radio device.

[0002] In exemplary embodiments, the antenna is of dimensions permitting its positioning within, or carriage together with, a hand-carriable mobile station while providing operability over a wide range of frequencies. The antenna is formed of a set of antenna patches that are configured together in a tri-dimensional arrangement. The spatial requirements of the antenna are reduced by folding one of the patches to cause contiguous portions thereof to extend in planar directions offset from that of another of the antenna patches. The antenna is operable with a multi-mode radio device that operates at multiple, spaced frequency bands.

Background of the Invention

[0003] Mobile communications have become pervasive throughout modem society. Ready access to a mobile communication system is, for many, a practical necessity. A cellular, or cellular-like communication system is an exemplary mobile radio communication system whose availability is widespread throughout significant portions of the populated areas of the world.

[0004] A cellular communication system is constructed generally to be in conformity with operational requirements set forth in an operating specification promulgated by a standards-setting body. The operating specification, amongst other things, defines a radio air interface extending between communication stations, i.e., the network infrastructure and a mobile station, operable in the communication system. Regulatory bodies allocate portions of the electromagnetic spectrum. Different allocations are made for different types of systems, and different regulatory bodies regulate the use of the electromagnetic spectrum in different jurisdictions. And, operating standards associated with different communication systems define operating parameters including parameters associated with the frequencies upon which the radio air interface is defined.

[0005] While early implementations of mobile stations used to communicate in a cellular communication system were relatively bulky, and were relatively heavy, advancements in integrated-circuit, processing, and communication technologies have permitted the miniaturization of newer implementations of mobile stations. Mobile stations are now regularly of dimensions permitting their hand-carriage. And, increasingly, mobile stations are constructed to be operable in conformity with the operating requirements of more than one operating standard. Such a mobile station, referred to as a multi-mode mobile station, is capable of operation pursuant to a communication service by way of any communication system with which the multi-mode mobile station is operable.

[0006] Miniaturization of a mobile station provided as a result of the technological advancements noted-above has permitted the circuitry required for multi-mode mobile station to be housed in a housing of small dimension. Multi-mode mobile stations are, for example, sometimes of configurations permitting their carriage in a shirt pocket of the user. Miniaturization is provided, not only by reducing the physical dimensions of the circuit paths of the receive and transmit chains of the circuitry of the mobile station, but also through sharing of circuit components between circuit paths used for communications pursuant to the different communication systems.

[0007] Miniaturization of antenna elements presents unique challenges, particularly when the antenna element is to form part of a multi-mode mobile station, operable at disparate frequency bands. An antenna element is generally most effective in transducing signal energy when the transducer is of dimensions related to the wavelength of the signal energy that is to be transduced. For instance, antenna lengths corresponding to, or multiples of, one-quarter wavelengths of the signal energy that is to be transduced exhibit good antenna characteristics. When the mobile station forms a multi-mode mobile station that operates at different frequency bands, different sizes of antennas are needed to transduce the signal energy of the different the circuitry of a multi-mode mobile station continue to decrease, dimensional requirements of the antenna elements are sometimes a limiting factor limiting further miniaturization of a mobile station. Significant effort has therefore been exerted to construct an antenna, operable over multiple frequency bands, that is also of small dimension, thereby to permit its positioning within the housing of a mobile station.

[0008] A PIFA (Planar Inverted-F Antenna) is sometimes utilized to transduce signal energy at a mobile station. Generally, a PIFA is of compact size and is of a low profile while providing for transducing of signal energy at more than one frequency band. A problem typically exhibited with a PIFA, however, is that a PIFA generally exhibits pass bands of narrow bandwidths. A bandwidth of a PIFA is enhanced by configuring the PIFA together with a parasitic element. Such use of a parasitic element, however, increases the dimensions of the antenna. Additionally, tuning of the antenna becomes more difficult due to the additional resonant branches. Also, the branches sometimes introduce EMI (Electromagnetic Interference) that interferes with antenna operation.

[0008A] U.S. pre-grant publication 2003/0142022 discloses an apparatus and method for tuning the patches of a multi-band antenna using transmission lines, which inherently use up space in a mobile device. PCT application KR01/01673 discloses a multi-band antenna, however, the antenna disclosed in that prior art reference is difficult to tune because the tuning is effectuated by slits formed in the radiating elements. PCT application EP 2003/006199 also discloses a multi-band antenna, however, the disclosed antenna uses a multi-level radiator that requires a lot of space.

[0009] An improved antenna structure, of small dimensions, and operable to transduce signal energy at multiple, disparate frequency bands is therefore needed.

[0010] It is in light of this background information related to radio communications that the significant improvements of the present invention have evolved.

[0010a] The invention is defined in the independent claims. Some optional features of the invention are defined in the dependent claims.

Brief Description of the Drawings

[0011] Figure 1 illustrates a functional block diagram of a radio communication system in which an embodiment of the present invention is operable.

[0012] Figure 2 illustrates a representation of the configuration of the antenna of an embodiment of the present invention.

[0013] Figure 3 illustrates a representation of the antenna shown in Figure 2, here in which the antenna is configured with folds formed in the folded patch portion thereof.

[0014] Figure 4 illustrates a representation of an exemplary return loss, plotted as a function of frequency, of an exemplary antenna of an embodiment of the present invention.

[0015] Figures 5 and 6 represent exemplary radiation patterns exhibited by the antenna of an embodiment of the present invention at two separate frequencies, at 950 MHz and 1880 MHz, respectively.

[0016] Figure 7 illustrates a method flow diagram representative of method of operation of an embodiment of the present invention.

Detailed Description

[0017] The present invention, accordingly, advantageously provides an antenna, and an associated methodology for transducing signal energy at a radio device, such as a portable mobile station.

[0018] Through operation of an embodiment of the present invention, an antenna is provided for the radio device. The antenna is of compact dimensions that permits its positioning within, or carriage together with, a mobile station. The antenna characteristics of the antenna permit its operation at selected frequency bands over a wide range of frequencies.

[0019] The antenna includes a set of antenna patches that are configured together in a tri-dimensional arrangement that extends in multiple planar directions. Reduction in the spatial requirements of the antenna is provided by the tri-dimensional configuration of the antenna. One of the patches of the set of antenna patches is forwarded such that contiguous portions thereof extend in planar directions offset from that of a portion contiguous thereto. The antenna is configured to be operable at disparate frequency bands over a wide range of frequencies.

[0020] In another aspect of the present invention, a first patch of the antenna forms a first main radiation element. The first patch is L-shaped, forming an L-shaped patch. The first radiation element is resonant at a frequency band depending upon the length of the patch and its location of connection to the second patch of the antenna. The first main radiation element forming the L-shaped patch includes both a feed point connection and a ground connection that are connectable with corresponding portions of the circuitry of the mobile station. Signal energy generated at the mobile station circuitry is provided to the antenna at the feed point connection, and signal energy transduced into electrical form at the antenna is provided to the transceiver circuitry at the feed point connection. The L-shaped patch includes a lengthwise-extending leg piece and a foot piece extending outwardly therefrom. Appropriate selection of the dimensions of the leg piece and of the foot piece are determinative, together with the location of the connection of the L-shaped patch with the second antenna patch, of the characteristics of the first antenna patch.

[0021] In another aspect of the present invention, the second antenna patch forms a folded patch, formed of multiple folded portions. A first portion is contiguous to, and integral with, the L-shaped patch forming the first antenna patch. The first portion is folded to extend in a planar direction offset from that of the planar direction in which the L-shaped first antenna patch extends. The first folded portion of the folded antenna patch extends, e.g., in a planar direction substantially perpendicular to the planar direction in which the L-shaped, first antenna patch extends. The folded antenna patch further includes a second folded portion, formed contiguous to, and integral with, the first folded portion. The second folded portion is folded to extend in a direction offset from the planar direction in which the first folded section extends. The second folded portion extends in a direction, e.g., substantially perpendicular to the planar direction in which the first folded portion extends. And, the folded antenna patch further includes a third folded portion, formed contiguous to and integral with the second folded portion. The third folded portion extends, e.g., in a direction substantially perpendicular to the planar direction in which the second folded portion extends. Thereby, the spatial requirements of the second antenna patch are reduced relative to the space that the second antenna patch would be required to be provided if the antenna were not folded.

[0022] In another aspect of the present invention, the folded, second antenna patch includes a tuning strip, tunable to be of a length to cause the antenna patch to include resonant frequencies at a desired frequency range.

[0023] In one implementation, the antenna forms a pent-band antenna, capable of operation at five disparate frequency bands, including the 850, 900, 1800, 1900, and 2200 MHz frequency bands. In other implementations, the antenna is configured to be resonant at other, and other numbers of, frequency bands. When connected to transceiver circuitry capable of operating in conformity with communication systems at the corresponding frequencies, the antenna permits signal energy to be transduced at any of the resonant frequencies. Due to its compact size, the antenna facilitates increased miniaturization of a mobile station, permitting its positioning within the housing of the mobile station.

[0024] In these and other aspects, therefore, an antenna, and an associated methodology is provided for a radio communication device. A first patch forms a first radiation element. The first patch is defined in a first planar direction and is resonant at least at a first higher frequency band. A second patch forms a second resonant element. The second patch includes a contiguous first portion, contiguous and integral with, the first patch. The contiguous first portion is folded to be upstanding beyond the first planar direction in which the first patch extends. Thereby, the contiguous first portion extends in a second planar direction. The second patch is resonant at a lower frequency band and a second higher frequency band. The first and second higher frequency bands are, e g., of corresponding, overlapping, or differing frequencies.

[0025] Referring first, therefore, to Figure 1, a radio communication system, shown generally at 10, provides for communication services, with mobile stations, of which the mobile station 12 is representative, by way of radio links defined upon a radio air interface 14. While the mobile station is generally representative of a mobile station operable in conformity with operating protocols of any of various operating specifications, in the exemplary implementation, the mobile station is operable to communicate at the 850, 900, 1800, 1900, and 2200 MHz frequency bands that correspond to 4 GSM (Global System for Mobile communications) frequency bands and a UMTS (Universal Mobile Telephone Service) band. Operability of the mobile station at the GSM frequencies and the UMTS frequencies provides a mobile station that is permitting of operation in a majority of the world-wide areas that provide for cellular-type communications.

[0026] A plurality of radio access networks (RANs), radio access networks 16, 18, 22, 24, and 26 are illustrated in Figure 1. The radio access networks 16-26 are representative, respectively, of a GSM 850 MHz system, a GSM 900 MHz system, a GSM 1800 MHz system, a GSM 1900 MHz system, and a UMTS 2200 MHz network, respectively. When the mobile station 12 is positioned within the coverage area of any of such networks 16-26, the mobile station is capable of communicating with the radio access network. Here, merely for purposes of simplicity, the mobile station is positioned within the coverage of each of the radio access networks. That is to say, in the illustrated example, all of the networks have overlapping coverage areas. In an actual implementation, various of the networks are implemented in separate, and non-overlapping, jurisdictional areas. The radio access networks 16-26 are coupled, here by way of gateways (GWYs) 28 to a core network 30. A communication endpoint (CE) 32 is coupled to the core network. The communication endpoint is representative of a communication device that communicates with the mobile station.

[0027] The mobile station sends data upon the radio air interface 14 and receives data communicated thereon. Transceiver circuitry 36 is embodied at the mobile station, formed of a transmit part and a receive part to operate upon data that is to be communicated by the mobile station or data that is received thereat. The receive and transmit chains forming the receive and transmit parts, respectively, of the transceiver circuitry are operable in conformity with the operating standards and protocols associated with, and defining, the respective systems. The transceiver circuitry of the mobile station is coupled to an antenna 42 of an embodiment of the present invention. The antenna is constructed to permit its operation to transduce signal energy at all of the frequency bands at which the mobile station transceiver circuitry is operable. That is to say, in the exemplary implementation, the antenna 42 operates to transduce signal energy at any of the 850, 900, 1800, 1900, and 2200 MHz frequency bands. In the exemplary implementation, the antenna is positioned within the housing 44 of the mobile station to be supportively enclosed by the housing. Howsoever positioned, the antenna is of small dimensions, facilitating its carriage together with the mobile station at any of the frequencies at which the mobile station operates.

[0028] Figure 2 illustrates the antenna 42, shown in Figure 1 to form part of the mobile station 12. The exemplary implementation shown in Figure 2 forms a pentband, i.e., a five-band, antenna that operates in conjunction with a five-band mobile station to transduce signal energy during its operation. The view shown in Figure 2 is representative of the antenna prior to configuration into a tri-dimensional form. The view is that of the pattern of the antenna. And, once formed, the antenna is folded at folds 48, 52, and 54, as shall be described below. By forming the folds in the antenna, the antenna is shaped into three dimensions to be tri-dimensional in shape. As each of the folds taken along the respective folding lines, in the exemplary implementation, forms a substantially perpendicular angle, the resultant form of the antenna is substantially rectangular.

[0029] The antenna includes two antenna patches, a first antenna patch 58 and a second antenna patch 62. The first antenna patch 58 here comprises an L-shaped patch including a lengthwise-extending leg part 64 and an outwardly-extending foot part 66. An outer lengthwise dimension of the L-shaped patch extends in a linear direction along the entire length of the patch. An inner lengthwise dimension, also extending in the same linear direction, is of a length that extends to the foot part and is of a length, in part, dependent upon the positioning and configuration of the foot part. The first antenna patch is connected to the transceiver circuitry (shown in Figure 1) of the mobile station at a feed point connection 72 and a ground connection 74. The first antenna patch is resonant at a frequency band of frequencies determined by the characteristics of the antenna patch. Through appropriate selection of the lengthwise dimension of the patch, i.e., the length of the leg piece of the L-shaped patch together with the location of connection of the second antenna patch is, in significant part, determinative of the operable frequency band of the first antenna patch. In the exemplary, pent-mode embodiment, the first antenna patch is configured to exhibit a resonant band of a relatively high frequency.

[0030] The second antenna patch 62 forms a folded patch with three portions, a first portion 78, a second portion 82, and a third portion 84 defined by the folding lines 48, 52, and 54, respectively. That is to say, the portion 78, 82, and 84 are defined by the folding of the antenna patch at the fold lines. The first portion is constructed to be contiguous to, and integral with, portions of the first antenna patch 58. When folded about the fold line 48, the portion 78 extends in a second planar direction, offset from a first planar direction in which the first antenna patch extends. The planar directions are offset, e.g., by ninety degree angles to be perpendicular to one another.

[0031] The second portion 82 is formed contiguous to, and integral with, the first portion 78. Folding of the second portion about the fold line 52 causes the second portion to extend in a third planar direction, offset from the second planar direction in which the portion 78 extends. In the exemplary implementation, the angle formed by folding of the antenna patch about the fold line 54 forms a substantially perpendicular angle to cause the third portion to extend in a planar direction substantially perpendicular to the planar direction of the second portion. The three portions of the second antenna patch and the first antenna patch define four planar directions that, when perpendicular, together define a rectangular shape.

[0032] The second portion 82 of the antenna patch 62 includes a tuning strip that is of a length that is determinative of one of the frequency ranges, and hence bands, at which the antenna is resonant. And, the length of the patch, in the lengthwise direction, independently determines resonant frequencies at a lower frequency band and at a high frequency band. Tuning of the lower frequency is provided by the selection, or change, of the configuration of the tuning strip.

[0033] Figure 3 again illustrates the antenna 42, shown previously in Figures 1 and 2. The antenna is here positioned at a substrate 92 at which the transceiver circuitry 36 is mounted. The transceiver circuitry is connected by way of conductive paths 94 with the feed point connection and the ground connection 72 and 74, respectively. The antenna is mounted upon a substrate part 98 that, in the exemplary implementation forms a FR-4 dielectric substrate of a thickness of 1.5 millimeters and is of a relative permittivity of 4.4. Folded as shown, the second portion 82 of the second antenna patch is upstanding beyond the first antenna patch 58. The first portion 78 is of a height of 10 millimeters in the exemplary implementation. And, the ground panel size is 55 millimeters by 90 millimeters. The conductive paths of the first and second antenna patches of the antenna are of lengths and widths that are resonant at selected frequency ranges, selected in the exemplary implementation to be resonant at five frequency ranges, including the 850, 900, 1800, 1900, and 2200 MHz bands. And, a lower frequency band width extends between 824 and 961 MHz while a higher frequency band width extends from 1700 to 2200 MHz. Appropriate selection of the dimensions of the first antenna patch extends the bandwidth of the higher frequency band to extend between 1600 and 2300 MHz. Due to the folded nature of the second antenna patch, the space required on the substrate 92/98 is reduced relative to a two-dimensional implementation.

[0034] Figure 4 illustrates a graphical representation 104 that shows exemplary return loss of an exemplary antenna 42 shown in any of the preceding figures. Review of the representation illustrates pass bands 106, 108, and 112. Through appropriate selection of the configuration of the antenna, the pass bands are located at other frequencies.

[0035] Figures 5 and 6 illustrate exemplary radiation patterns exhibited by the antenna 42 in an exemplary implementation. In Figure 5, a first plot 118 is representative of the radiation pattern at 950 MHz in the YZ plane. And, the curve 122 is representative of a second radiation pattern, also at the 950 MHz frequency, but in an XY plane.

[0036] Analogously, in Figure 6, a first radiation pattern 128 is representative of the radiation pattern at 1880 MHz in the YZ plane. And, the radiation pattern 132 is representative of the radiation pattern, at the same frequency, but in the XY plane.

[0037] Figure 7 illustrates a method flow diagram shown generally at 142, representative of the method of operation of an embodiment of the present invention. The method transuces signal energy at a radio device.

[0038] First, and as indicated by the block 144, a first radiation element is formed, comprised of a first patch defined to extend in a first planar direction and resonant at a first frequency band. Then, and as indicated by the block 146, a second radiation element is formed. The second radiation element includes a folded loop having a contiguous first portion. The contiguous first portion is contiguous and integral with the first patch. The second radiation element also includes a contiguous second portion, contiguous and integral with the first portion. The contiguous first portion is folded to be upstanding beyond the first patch in a second planar direction and the contiguous second portion is folded to extend in a third planar direction, offset from the second planar direction. The second radiation element is resonant at a second frequency band. The second radiation element further includes a contiguous third portion, contiguous and integral with the contiguous second portion. The contiguous third portion extends in a fourth planar direction, offset from the third planar direction. In one implementation, the element is formed such that the second and fourth planar directions are substantially parallel and such that the third planar direction is substantially parallel to the first planar direction in which the first element extends.

[0039] Then, and as indicated by the block 148, the folded loop is tuned. And, as indicated by the block 152, signal energy is transduced within any of the first and second frequency bands at any of the first patch and the folded loop.

[0040] Due to the tri-dimensional configuration of the antenna, a multi-band antenna is formed, of compact configuration, facilitating its use together with a mobile station, or other portable radio device.

[0041] Presently preferred embodiments of the invention and many of its improvements and advantages have been described with a degree of particularity. The description is of preferred examples of implementing the invention, and the description of preferred examples is not necessarily intended to limit the scope of the invention. The scope of the invention is defined by the following claims.

Claims

1. An antenna (42) for a pent-band radio communication for connection to a radio transceiver circuitry, said antenna (42) being mounted upon a substrate (98) and comprising:

    a first patch (58) forming a first radiation element, said first patch being L-shaped and having a lengthwise-extending leg part (64) and an outwardly-extending foot part (66), a lengthwise dimension of the L-shaped patch extending in a linear direction along an entire length of the patch, an inner lengthwise dimension also extending in the linear direction to the outwardly-extending foot part, the first antenna patch including a feed point connection (72) extending from and contiguous with the first antenna patch, the first antenna patch being connected to the radio transceiver circuitry, at the feed point connection (72) and at a ground connection (74) for said antenna (42), the first antenna patch being configured to resonate at a frequency determined by the lengthwise dimension of the L-shaped patch and by a location of a connection of a second folded antenna patch (62) to the first antenna patch, said first patch being resonant at least at a first higher frequency band; wherein the second folded antenna patch (62) forming a second radiation element, and including a first portion (78), a second portion (82) and a third portion (84), said first portion (78), being contiguous and integral with said first patch (58), the first portion (78) of the second folded antenna patch (62) being folded to extend in a second planar direction substantially perpendicular to a first planar direction of the first patch, the second portion (82) of the second folded patch (62) being contiguous and integral with the first portion (78) and being folded to extend in a third planar direction, the second portion (82) having a tuning strip (88) of a length determinative of one of the frequency ranges of the antenna (42), the third portion of the second folded antenna patch (62) being folded to extend in a fourth planar direction substantially perpendicular to the second portion, the second patch (62) resonant at least at a lower frequency band and a second higher frequency band.

2. The antenna (42) of claim 1, wherein the first higher frequency band at which first patch (58) is configured to be resonant is dependent upon a lengthwise dimension of the lengthwise-extending leg part (64) part of the first patch.

3. The antenna (42) of claim 2 wherein the lengthwise dimension of the L-shaped patch (64) comprises an inner lengthwise dimension determined by positioning of the foot piece (66) relative to the elongated leg piece (64).

4. The antenna (42) of claim 2 wherein the lengthwise dimension of the elongated leg piece (64) comprises an outer lengthwise dimension defining an entire length of the leg piece (64).

5. The antenna (42) of claim 1 wherein the first higher frequency band at which the first radiation element (58) forming said first patch is resonant is positioned between 1600 MHz and 2300 MHz.

6. The antenna (42) of claim 1 wherein the first higher frequency band at least overlaps with the second higher frequency band.

7. The antenna (42) of claim 1 wherein said first patch (58) is further configured to include a communication-device feed point (72) connection.

8. The antenna (42) of claim 1 wherein said first patch (58) is further configured to include a communication-device ground connection (74).

9. The antenna (42) of claim 1 wherein the third planar direction in which the second portion (82) extends is substantially perpendicular to the second planar direction in which the first portion (78) extends.

10. The antenna (42) of claim 1 wherein the second higher frequency band at which the second radiation element forming said second patch (62) is configured to be resonant is dependent upon a lengthwise dimension of said second patch (62).

11. The antenna (42) of claim 1 wherein the second radiation element forming said second patch (62) further comprises a tuning strip of a tuning-strip length, a lengthwise dimension of the tuning strip determinative, in part, of the lower frequency band at which said second patch (62) is resonant.

12. The antenna (42) of claim 1 wherein the first higher frequency band encompasses 1600-2300 MHz and wherein the second higher frequency band encompasses 1700-2200 MHz.

13. The antenna (42) of claim 1 wherein the lower frequency band at which said second patch (62) is resonant comprises a frequency band within a 824 MHz to 961 MHz rang and wherein the second higher frequency band comprises a frequency band within a 1700 MHz to 2200 MHz range.

14. A method (142) for transducing signal energy at a pent-band radio device, said method comprising the operations of:

forming a first L-shaped radiation element (144) comprised of a first patch defined to extend in a first planar direction and resonant at a first higher frequency band, said first patch having: a lengthwise-extending leg part (64) and an outwardly-extending foot part (66), a lengthwise dimension of the L-shaped patch extending in a linear direction along an entire length of the patch and an inner lengthwise dimension also extending in the linear direction to the outwardly-extending foot part, the first antenna patch including a feed point connection (72) extending from and contiguous with the first antenna patch, the first antenna patch for connection to radio transceiver circuitry at the feed point connection (72) and at a ground connection (74) for said antenna (42), the first antenna patch being resonant at a frequency determined by the lengthwise dimension of the L-shaped patch and by a location of a connection of a second folded antenna patch (62) to the first antenna patch;

forming a second radiation element (146) comprised of the second folded antenna patch being contiguous and integral with the said first patch and having a first portion (78), a second portion (82) and a third portion (84), the first portion (78) of the second folded patch being folded to extend in a second planar direction substantially perpendicular to a first planar direction of the first patch, the second portion (82) of the second folded patch (62) being contiguous and integral with the first portion (78) and being folded to extend in a third planar direction, the second portion (82) having a tuning strip (88) of a length determinative of one of the frequency ranges of the antenna (42), the third portion (84) of the second folded antenna patch (62) being folded to extend in a fourth planar direction substantially perpendicular to the second portion, the second radiation element resonant at least at a lower frequency band and a second higher frequency band;

mounting the antenna (42) on a substrate (98) and connecting the antenna to the radio transceiver circuitry; and

transducing (152) signal energy within any of the higher and lower frequency bands at any of the first patch and the tuning strip (88).

15. The method (142) of claim 14 comprising the further operation of tuning the tuning strip (88).

Patentansprüche

1. Eine Antenne (42) für eine Pent-Band-Funkkommunikation zur Verbindung mit einer Funk-Transceiver-Schaltung, wobei die Antenne (42) auf einem Substrat (98) angebracht ist und aufweist:

einen ersten Patch (58), der ein erstes Ausstrahlungselement bildet, wobei der erste Patch L-förmig ist und einen sich längs erstreckenden Schenkelteil (64) und einen sich nach außen erstreckenden Fußteil (66) hat, wobei sich eine Längendimension des L-förmigen Patches in einer linearen Richtung entlang einer gesamten Länge des Patches erstreckt,

wobei sich eine innere Längendimension ebenfalls in der linearen Richtung zu dem sich nach außen erstreckenden Fußteil erstreckt, wobei der erste Antennen-Patch eine Zufuhrpunkt-Verbindung (72) umfasst, die sich von und angrenzend zu dem ersten Antennen-Patch erstreckt, wobei der erste Antennen-Patch mit der Funk-Transceiver-Schaltung verbunden ist an der Zufuhrpunkt-Verbindung (72) und an einer Masse-Verbindung (74) für die Antenne (42), wobei der erste Antennen-Patch konfiguriert ist, bei einer Frequenz eine Resonanz zu haben, die durch die Längendimension des L-förmigen Patches und durch eine Position einer Verbindung eines zweiten gefalteten Antennen-Patches (62) zu dem ersten Antennen-Patch bestimmt wird, wobei der erste Patch zumindest an einem ersten höheren Frequenzband resonant ist; wobei

der zweite gefaltete Antennen-Patch (62) ein zweites Ausstrahlungselement bildet, und einen ersten Abschnitt (78), einen zweiten Abschnitt (82) und

einen dritten Abschnitt (84) umfasst, wobei der erste Abschnitt (78) angrenzend und integral mit

dem ersten Patch (58) ist, wobei der erste Abschnitt (78) des zweiten gefalteten Antennen-Patches (62) gefaltet ist,
um sich in einer zweiten planaren Richtung im Wesentlichen senkrecht zu einer ersten planaren Richtung des ersten Patches zu erstrecken, wobei der zweite Abschnitt (82) des zweiten gefalteten Patches (62) angrenzend und integral mit dem ersten Abschnitt (78) ist und gefaltet ist, um sich in einer dritten planaren Richtung zu erstrecken, wobei der zweite Abschnitt (82) einen Tuning-Streifen (88) einer Länge hat, die einen der Frequenzbereiche der Antenne (42) bestimmt, wobei der dritte Abschnitt des zweiten gefalteten Antennen-Patches (62) gefaltet ist, um sich in einer vierten planaren Richtung im Wesentlichen senkrecht zu dem zweiten Abschnitt zu erstrecken, wobei der zweite Patch (62) zumindest in einem niedrigeren Frequenzband und einem zweiten höheren Frequenzband resonant ist.

2. Die Antenne (42) gemäß Anspruch 1, wobei das erste höhere Frequenzband, an dem der erste Patch (58) konfiguriert ist, resonant zu sein, abhängig ist von einer Längendimension des sich längs erstreckenden Schenkelteils (64) des ersten Patches.

3. Die Antenne (42) gemäß Anspruch 2, wobei die Längendimension des L-förmigen Patches (64) eine innere Längendimension aufweist, die durch Positionieren des Fußteils (66) relativ zu dem länglichen Schenkelteil (64) bestimmt wird.

4. Die Antenne (42) gemäß Anspruch 2, wobei die Längendimension des länglichen Schenkelteils (64) eine äußere Längendimension aufweist, die eine gesamte Länge des Schenkelteils (64) definiert.

5. Die Antenne (42) gemäß Anspruch 1, wobei das erste höhere Frequenzband, in dem das erste Ausstrahlungselement (58), das den ersten Patch bildet, resonant ist, zwischen 1600 MHz und 2300 MHz positioniert ist.

6. Die Antenne (42) gemäß Anspruch 1, wobei das erste höhere Frequenzband mit dem zweiten höheren Frequenzband zumindest überlappt.

7. Die Antenne (42) gemäß Anspruch 1, wobei der erste Patch (58) weiter konfiguriert ist, eine Kommunikationsvorrichtungs-Zufuhrpunkt (72)-Verbindung zu umfassen.

8. Die Antenne (42) gemäß Anspruch 1, wobei der erste Patch (58) weiter konfiguriert ist, eine Kommunikationsvorrichtung-Masse-Verbindung (74) zu umfassen.

9. Die Antenne (42) gemäß Anspruch 1, wobei die dritte planare Richtung, in die sich der zweite Abschnitt (82) erstreckt, im Wesentlichen senkrecht zu der zweiten planaren Richtung ist, in die sich der erste Abschnitt (78) erstreckt.

10. Die Antenne (42) gemäß Anspruch 1, wobei das zweite höhere Frequenzband, in dem das zweite Ausstrahlungselement, das den zweiten Patch (62) bildet, konfiguriert ist, resonant zu sein, von einer Längendimension des zweiten Patches (62) abhängig ist.

11. Die Antenne (42) gemäß Anspruch 1, wobei das zweite Ausstrahlungselement, das den zweiten Patch (62) bildet, weiter aufweist einen Tuning-Streifen einer Tuning-Streifen-Länge, wobei eine Längendimension des Tuning-Streifens teilweise für das niedrigere Frequenzband bestimmend ist, in dem der zweite Patch (62) resonant ist.

12. Die Antenne (42) gemäß Anspruch 1, wobei das erste höhere Frequenzband 1600-2300 MHz umfasst und wobei das zweite höhere Frequenzband 1700-2200 MHz umfasst.

13. Die Antenne (42) gemäß Anspruch 1, wobei das niedrigere Frequenzband, in dem der zweite Patch (62) resonant ist, ein Frequenzband in einem Bereich von 824 MHz bis 961 MHz aufweist, und wobei das zweite höhere Frequenzband ein Frequenzband in einem Bereich von 1700 MHz bis 2200 MHz aufweist.

14. Ein Verfahren (142) zum Umwandeln von Signalenergie an einer Pent-Band-Funkvorrichtung, wobei das Verfahren die Operationen aufweist:

Bilden eines ersten L-förmigen Ausstrahlungselements (144), das einen ersten Patch aufweist, der definiert ist, sich in einer ersten planaren Richtung zu erstrecken und an einem ersten höheren Frequenzband resonant zu sein, wobei der erste Patch aufweist: einen sich längs erstreckenden Schenkelteil (64) und einen sich nach außen erstreckenden Fußteil (66), wobei sich eine Längendimension des L-förmigen Patches in einer linearen Richtung entlang einer gesamten Länge des Patches erstreckt und sich eine innere Längendimension ebenfalls in der linearen Richtung zu dem sich nach außen erstrekkenden Fußteil erstreckt, wobei der erste Antennen-Patch eine Zufuhrpunkt-Verbindung (72) umfasst, die sich von und angrenzend zu dem ersten Antennen-Patch erstreckt, wobei der erste Antennen-Patch vorgesehen ist zur Verbindung mit einer Funk-Transceiver-Schaltung an der Zufuhrpunkt-Verbindung (72) und an einer Masse-Verbindung (74) für die Antenne (42), wobei der erste Antennen-Patch an einer Frequenz resonant ist, die durch die Längendimension des L-förmigen Patches und durch eine Position einer Verbindung eines zweiten gefalteten Antennen-Patches (62) zu dem ersten Antennen-Patch bestimmt wird;

Bilden eines zweiten Ausstrahlungselements (146), das den zweiten gefalteten Antennen-Patch aufweist, der angrenzend und integral mit dem ersten Patch ist und einen ersten Abschnitt (78), einen zweiten Abschnitt (82) und einen dritten Abschnitt (84) umfasst, wobei der erste Abschnitt (78) des zweiten gefalteten Patches gefaltet ist, um sich in einer zweiten planaren Richtung im Wesentlichen senkrecht zu einer ersten planaren Richtung des ersten Patches zu erstrecken, wobei der zweite Abschnitt (82) des zweiten gefalteten Patches (62) angrenzend und integral mit dem ersten Abschnitt (78) ist und gefaltet ist, um sich in einer dritten planaren Richtung zu erstrekken, wobei der zweite Abschnitt (82) einen Tuning-Streifen (88) einer Länge hat, die einen der Frequenzbereiche der Antenne (42) bestimmt, wobei der dritte Abschnitt (84) des zweiten gefalteten Antennen-Patches (62) gefaltet ist, um sich in einer vierten planaren Richtung im Wesentlichen senkrecht zu dem zweiten Abschnitt zu erstrecken, wobei das zweite Ausstrahlungselement resonant ist zumindest in einem niedrigeren Frequenzband und einem zweiten höheren Frequenzband;

Anbringen der Antenne (42) auf einem Substrat (98) und Verbinden der Antenne mit der Funk-Transceiver-Schaltung; und

Umwandeln (152) von Signalenergie in einem der höheren und niedrigeren Frequenzbänder an einem des ersten Patches und des Tuning-Streifens (88).

15. Das Verfahren (142) gemäß Anspruch 14, das den weiteren Vorgang eines Anpassens des Tuning-Streifens (88) aufweist.

Revendications

1. Antenne (42) pour radiocommunication sur cinq bandes, destinée à être connectée à une circuiterie d'émission-réception radio, ladite antenne (42) étant montée sur un substrat (98) et comprenant :

une première pastille (58) formant un premier élément rayonnant, ladite première pastille ayant une forme de L et possédant une branche qui s'étend longitudinalement (64) et une partie d'extrémité qui s'étend vers l'extérieur (66), la dimension longitudinale de la pastille en forme de L s'étendant dans une direction longitudinale sur toute la longueur de la pastille et une dimension longitudinale intérieure s'étendant également dans la direction linéaire en direction de la partie d'extrémité qui s'étend vers l'extérieur, la première pastille d'antenne comprenant un point de connexion d'alimentation (72) qui s'étend à partir de la première pastille d'antenne et qui lui est contiguë, la première pastille d'antenne étant connectée à la circuiterie d'émission-réception par le point de connexion d'alimentation (72) et par une connexion de masse (74) de ladite antenne (42), la première pastille d'antenne étant configurée pour résonner à une fréquence déterminée par la dimension longitudinale de la pastille en forme de L et par une position d'une connexion d'une deuxième pastille d'antenne repliée (62) avec la première pastille d'antenne, ladite première pastille résonnant à au moins une première bande de fréquence supérieure ;

dans lequel la deuxième pastille d'antenne repliée (62) forme un deuxième élément rayonnant et comprend une première partie (78), une deuxième partie (82) et une troisième partie (84), ladite première partie (78) étant contiguë à ladite première pastille (58) et faite d'une pièce avec celle-ci, la première partie (78) de la deuxième pastille d'antenne repliée (62) étant repliée dans une deuxième direction plane qui est substantiellement perpendiculaire à la première direction plane de la première pastille, la deuxième partie (82) de la deuxième pastille d'antenne repliée (62) étant contiguë à la première partie (78) et faite d'une pièce avec celle-ci et étant repliée dans une troisième direction plane, la deuxième partie (82) possédant une bande de syntonisation (88) d'une longueur qui détermine une des bandes de fréquence de l'antenne (42), la troisième partie de la deuxième pastille d'antenne repliée (62) étant repliée pour s'étendre dans une quatrième direction plane substantiellement perpendiculaire à la deuxième partie, la deuxième pastille (62) résonnant au moins sur une bande de fréquence inférieure et sur une deuxième bande de fréquence supérieure.

2. Antenne (42) selon la revendication 1, dans laquelle la première bande de fréquence supérieure à laquelle la première pastille (58) est configurée pour résonner dépend d'une dimension longitudinale d'une branche de la première pastille qui s'étend longitudinalement (64).

3. Antenne (42) selon la revendication 2, dans laquelle la direction longitudinale de la pastille en forme de L (64) comprend une dimension longitudinale intérieure déterminée en implantant la partie d'extrémité (66) par rapport à la branche allongée (64).

4. Antenne (42) selon la revendication 2, dans laquelle la dimension longitudinale de la branche allongée (64) comprend une dimension longitudinale extérieure qui définit une longueur totale de la branche (64).

5. Antenne (42) selon la revendication 1, dans laquelle la première bande de fréquence supérieure à laquelle résonne le premier élément rayonnant (58) formant ladite première pastille se situe entre 1 600 MHz et 2 300 MHz.

6. Antenne (42) selon la revendication 1, dans laquelle la première bande de fréquence supérieure se superpose au moins à la deuxième bande de fréquence supérieure.

7. Antenne (42) selon la revendication 1, dans laquelle ladite première pastille (58) est en outre configurée pour comprendre une connexion de point d'alimentation (72) du dispositif de communication.

8. Antenne (42) selon la revendication 1, dans laquelle ladite première pastille (58) est en outre configurée pour comprendre une connexion de masse (74) du dispositif de communication.

9. Antenne (42) selon la revendication 1, dans laquelle la troisième direction plane dans laquelle s'étend la deuxième partie (82) est substantiellement perpendiculaire à la deuxième direction plane dans laquelle s'étend la première partie (78).

10. Antenne (42) selon la revendication 1, dans laquelle la deuxième bande de fréquence supérieure à laquelle le deuxième élément rayonnant formant ladite deuxième pastille (62) est configuré pour résonner dépend d'une dimension longitudinale de ladite deuxième pastille (62).

11. Antenne (42) selon la revendication 1, dans laquelle le deuxième élément rayonnant formant ladite deuxième pastille (62) comprend en outre une bande de syntonisation, possédant une longueur de syntonisation, la dimension longitudinale de la bande de syntonisation déterminant partiellement la bande de fréquence inférieure à laquelle résonne ladite deuxième pastille (62).

12. Antenne (42) selon la revendication 1, dans laquelle la première bande de fréquence supérieure couvre de 1 600 à 2 300 MHz et dans lequel la deuxième bande de fréquence supérieure couvre de 1700 à 2 00 MHz.

13. Antenne (42) selon la revendication 1, dans laquelle la bande de fréquence inférieure à laquelle résonne ladite deuxième pastille (62) comprend une bande de fréquence entre 824 MHz et 961 MHz et dans lequel la deuxième bande de fréquence supérieure comprend une bande de fréquence sur une plage de 1700 MHz à 2200 MHz.

14. Procédé (142) de transduction de l'énergie du signal sur un dispositif radio à cinq bandes, ledit procédé comprenant les étapes consistant à :

former un premier élément rayonnant en forme de L (144) comprenant une première pastille définie comme s'étendant dans une première direction plane et résonnant sur une première bande de fréquence supérieure, ladite première pastille possédant : une branche qui s'étend longitudinalement (64) et une partie d'extrémité qui s'étend vers l'extérieur (66), la dimension longitudinale de la pastille en forme de L s'étendant dans une direction linéaire sur toute la longueur de la pastille et une dimension longitudinale intérieure s'étendant également dans la direction linéaire en direction de la partie d'extrémité qui s'étend vers l'extérieur, la première pastille d'antenne comprenant un point de connexion d'alimentation (72) qui s'étend à partir de la première pastille d'antenne et qui lui est contiguë, la première pastille d'antenne étant connectée à la circuiterie d'émission-réception par le point de connexion d'alimentation (72) et par une connexion de masse (74) de ladite antenne (42), la première pastille d'antenne résonnant à une fréquence déterminée par la dimension longitudinale de la pastille en forme de L et par une position d'une connexion d'une deuxième pastille d'antenne repliée (62) avec la première pastille d'antenne ;

former un deuxième élément rayonnant (146) qui comprend la deuxième pastille qui est contiguë à ladite première pastille, qui est faite d'une pièce avec celle-ci et qui comprend une première partie (78), une deuxième partie (82) et une troisième partie (84), la première partie (78) de la deuxième pastille d'antenne repliée étant repliée dans une deuxième direction plane qui est substantiellement perpendiculaire à la première direction plane de la première pastille, la deuxième partie (82) de la deuxième pastille d'antenne repliée (62) étant contiguë à la première partie (78) et faite d'une pièce avec celle-ci et étant repliée dans une troisième direction plane, la deuxième partie (82) possédant une bande de syntonisation (88) d'une longueur qui détermine une des bandes de fréquence de l'antenne (42), la troisième partie (84) de la deuxième pastille d'antenne repliée (62) étant repliée dans une

quatrième direction plane substantiellement perpendiculaire à la deuxième partie, le deuxième élément résonnant au moins sur une bande de fréquence inférieure et sur une deuxième bande de fréquence supérieure ;
monter l'antenne (42) sur un substrat (98) et connecter l'antenne à la circuiterie d'émission-réception ; et
effectuer la transduction (152) de l'énergie du signal sur l'une des bandes de fréquence supérieure et inférieure, à l'aide de soit la première pastille, soit la bande de syntonisation (88).

15. Procédé (142) selon la revendication 14, comprenant en outre l'étape consistant à syntoniser la bande de syntonisation (88).

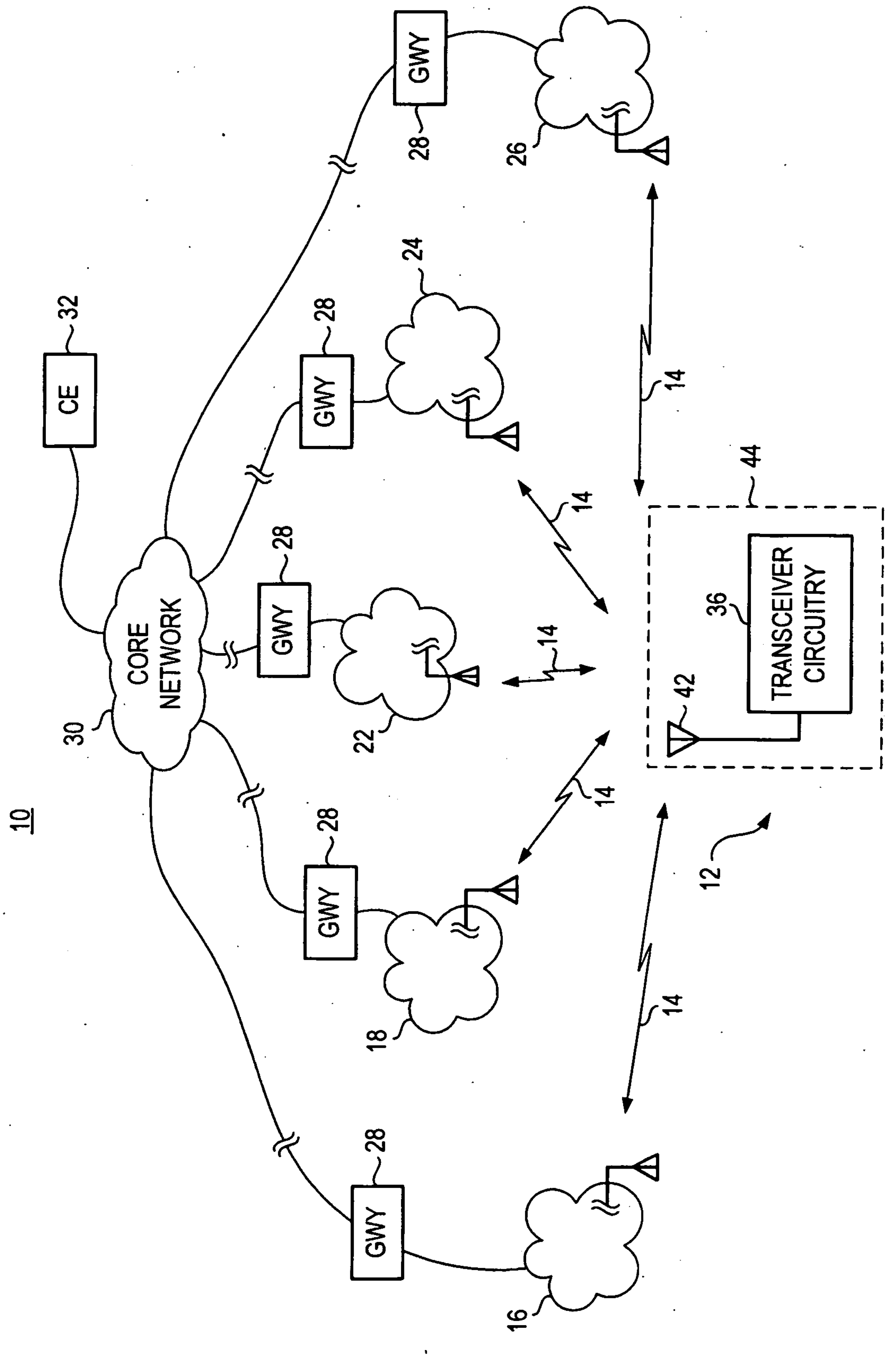
10
CE
32
CORE NETWORK
30
GWY
28
14
16
18
22
24
26
44
TRANSCEIVER CIRCUITRY
36
42
12

FIG. 1

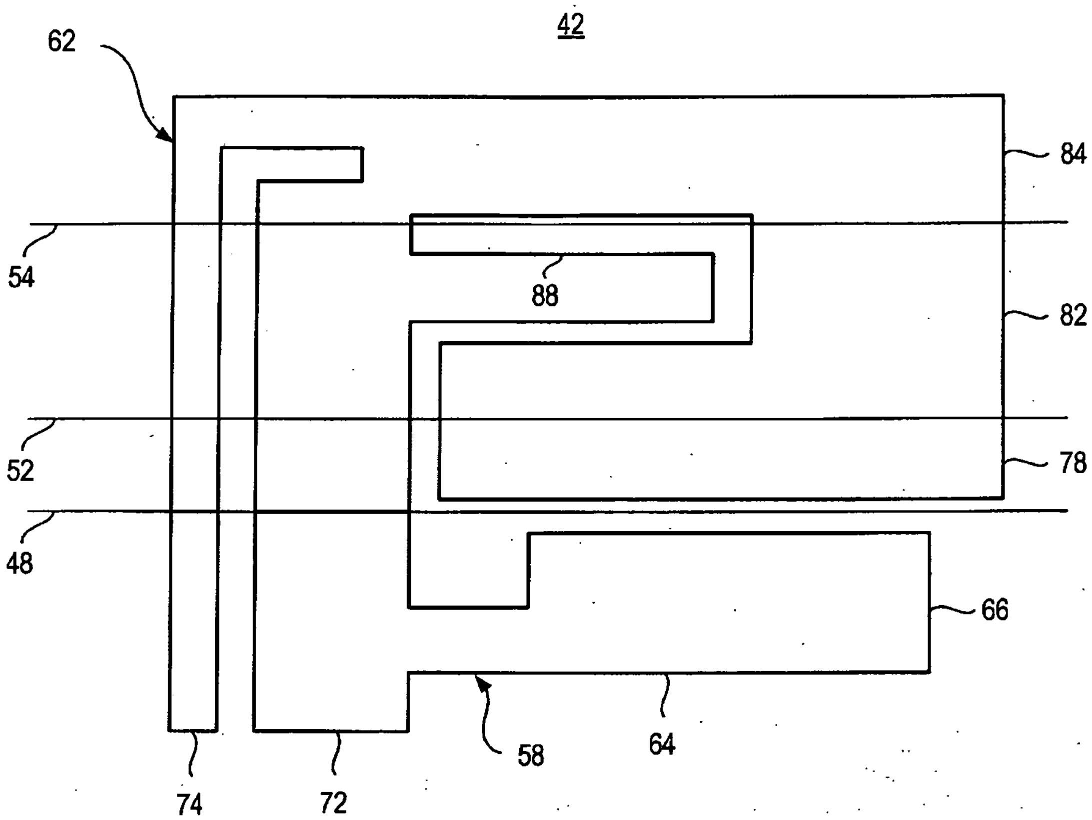

FIG. 2

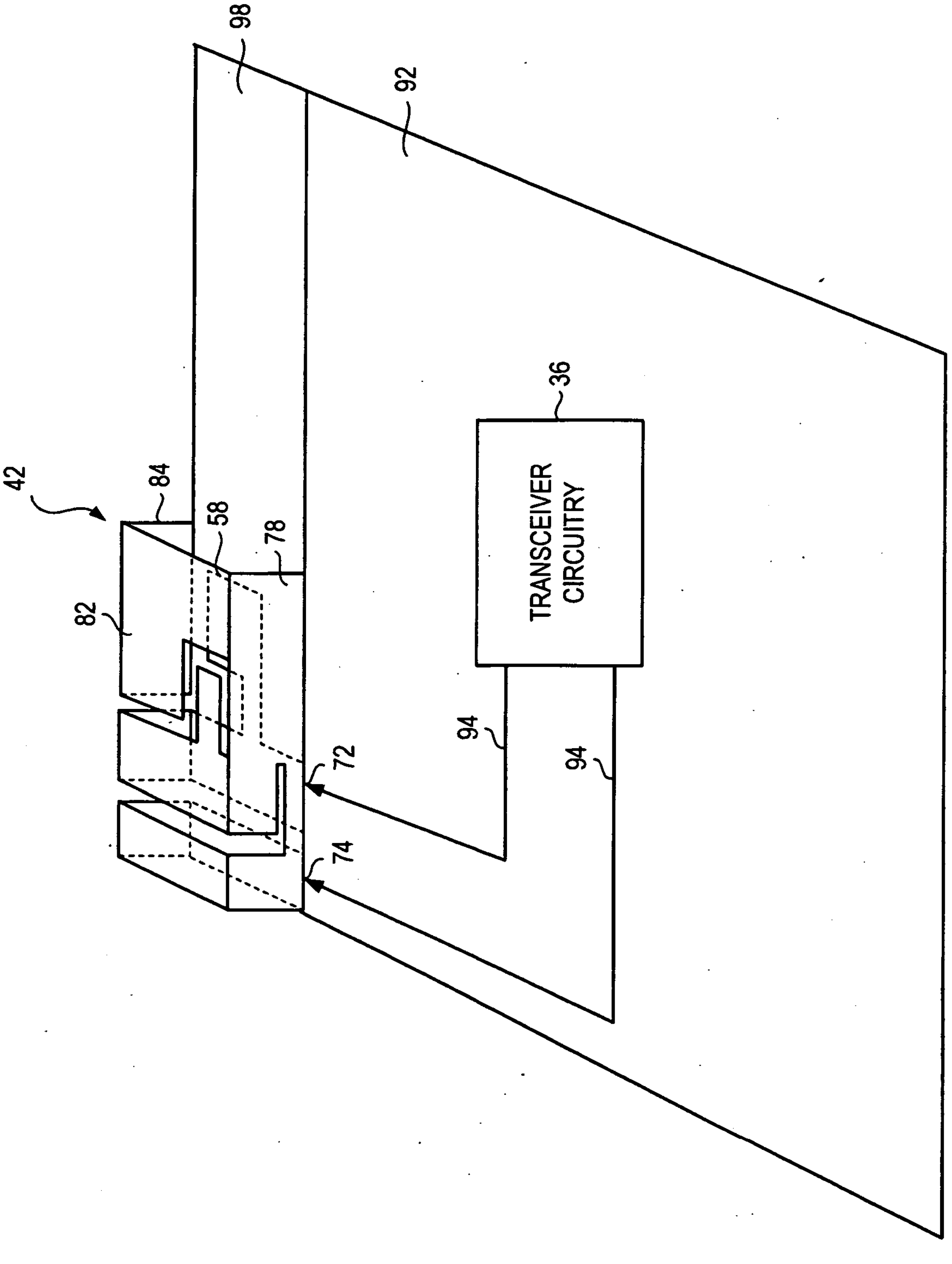

FIG. 3

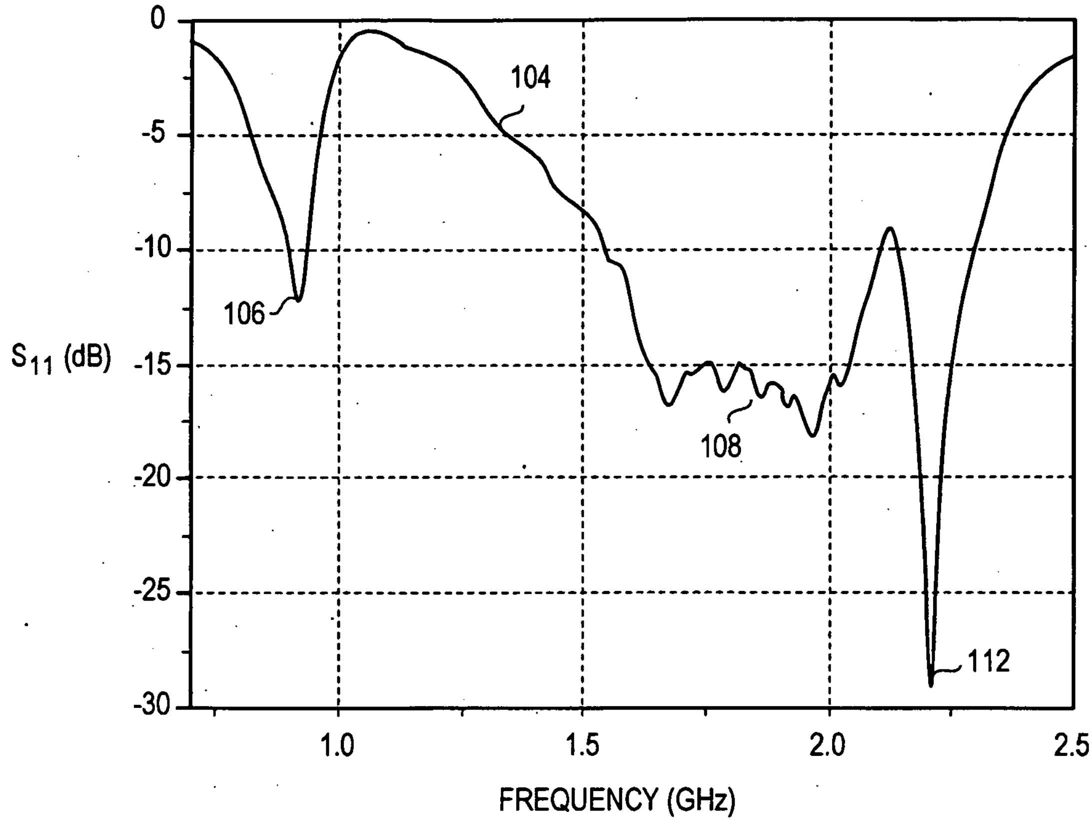

FIG. 4

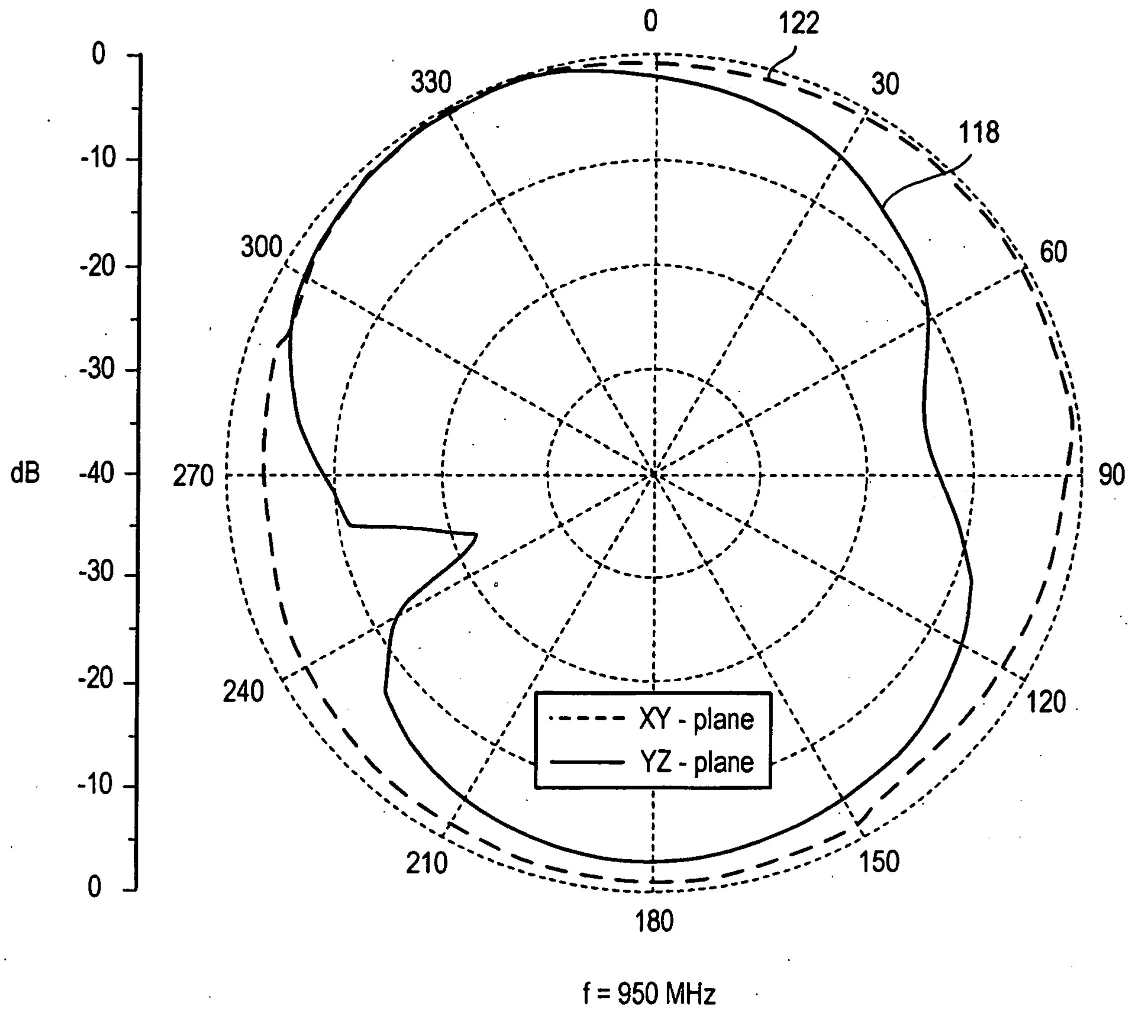
0
-10
-20
-30
dB
-40
-30
-20
-10
0
0
122
30
118
60
90
120
150
180
210
240
270
300
330
XY - plane
YZ - plane
f = 950 MHz

FIG. 5

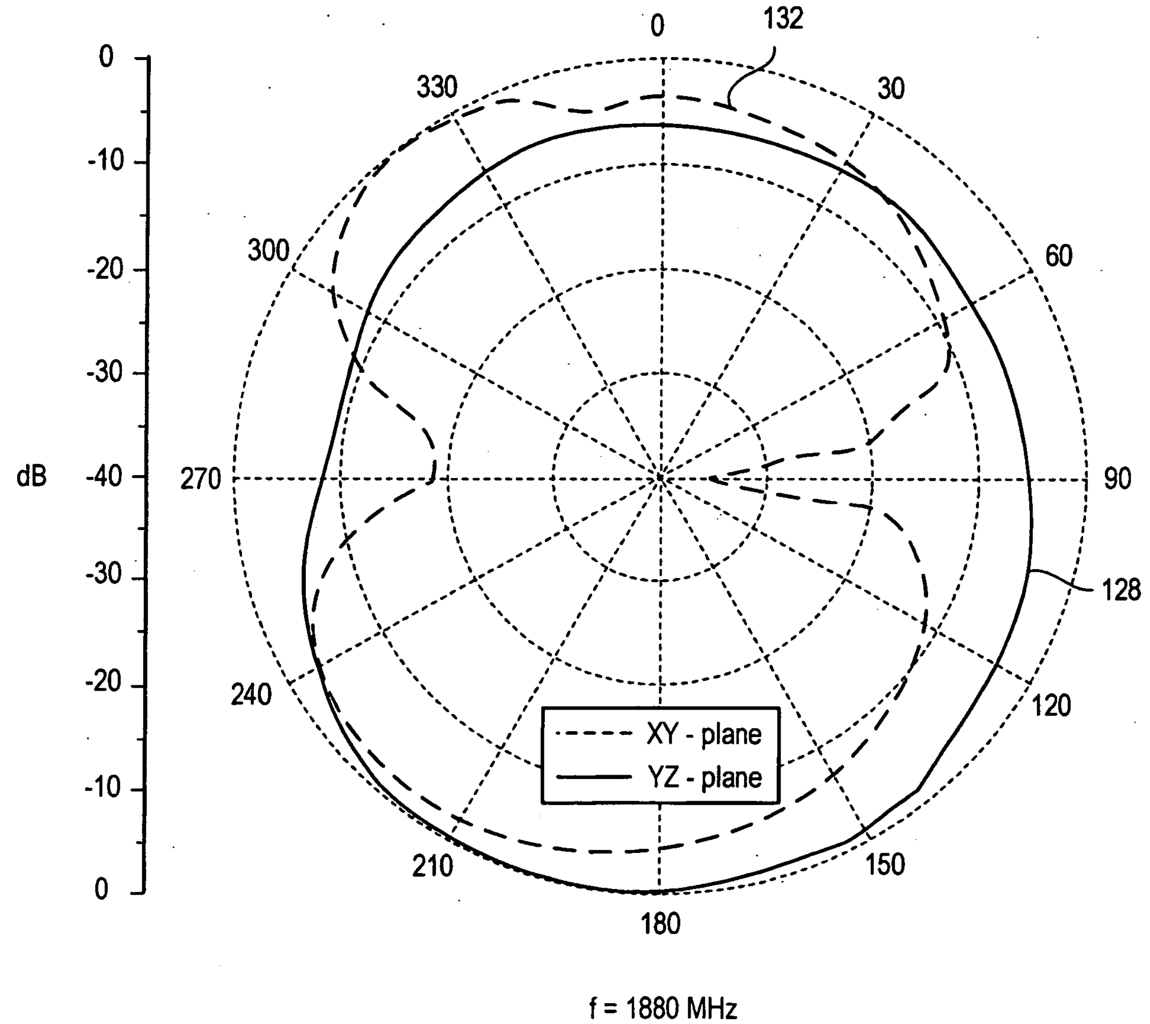
0
132
330
30
300
60
270
90
240
120
210
150
180
128
dB
0
-10
-20
-30
-40
-30
-20
-10
0
XY - plane
YZ - plane
f = 1880 MHz

FIG. 6

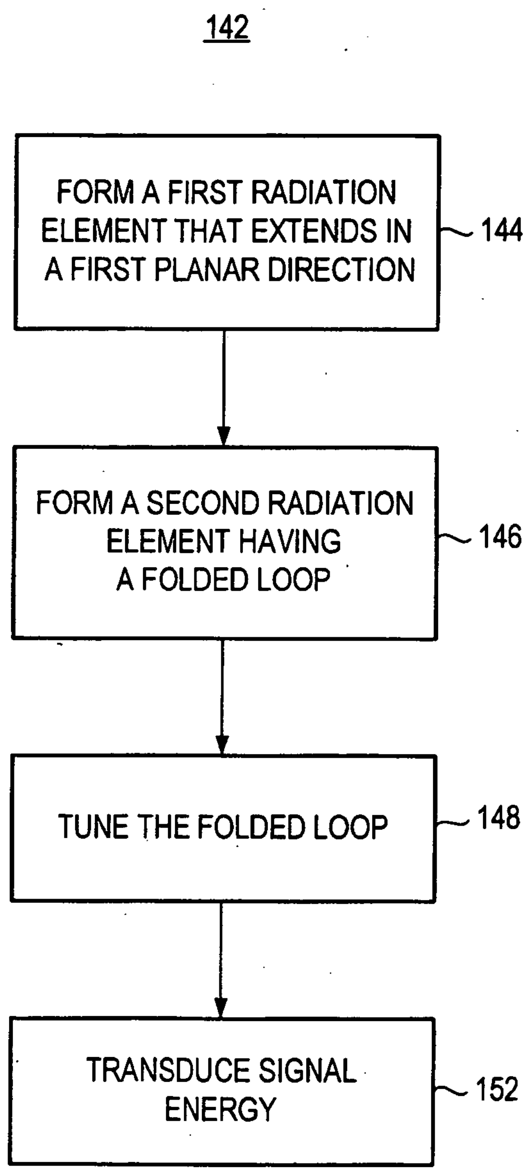
142
FORM A FIRST RADIATION ELEMENT THAT EXTENDS IN A FIRST PLANAR DIRECTION
144
FORM A SECOND RADIATION ELEMENT HAVING A FOLDED LOOP
146
TUNE THE FOLDED LOOP
148
TRANSDUCE SIGNAL ENERGY
152

FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- KR 0101673 W **[0008]**
- EP 2003006199 W **[0008]**