

(19)



(11)

EP 2 528 160 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.11.2012 Bulletin 2012/48

(51) Int Cl.:
H01Q 1/24 (2006.01) **H01Q 9/04** (2006.01)
H01Q 21/28 (2006.01)

(21) Application number: **11167349.7**

(22) Date of filing: **24.05.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(72) Inventor: **Ayatollahi, Mina**
Waterloo, Ontario N2L 3W8 (CA)

(74) Representative: **Noble, Nicholas et al**
Kilburn & Strode LLP
20 Red Lion Street
London WC1R 4PJ (GB)

(71) Applicant: **Research In Motion Limited**
Waterloo, ON N2L 3W8 (CA)

Remarks:

Amended claims in accordance with Rule 137(2) EPC.

(54) **Mobile wireless communications device having an antenna assembly with corner coupled rectangular base conductor portions and related methods**

(57) A mobile wireless communications device (30) may include a portable housing (31), a substrate (32) carried by the portable housing, and wireless communications circuitry (33) carried by the substrate. The mobile wireless communications device may also include at least one antenna assembly (40) carried by the substrate and coupled to the wireless communications circuitry. The at least one antenna assembly may include an electrically conductive base conductor (41) having a

first rectangular base portion (42a) and a second rectangular base portion (42b) offset therefrom. The first and second base portions may be coupled at respective diagonally opposing corners (48) thereof and having an antenna feed (43) defined along an outer portion of one of the first and second rectangular base portions. The at least one antenna assembly may include at least one electrically conductive arm (47) extending along at least one side of one of the first and second rectangular base portions and spaced apart therefrom.

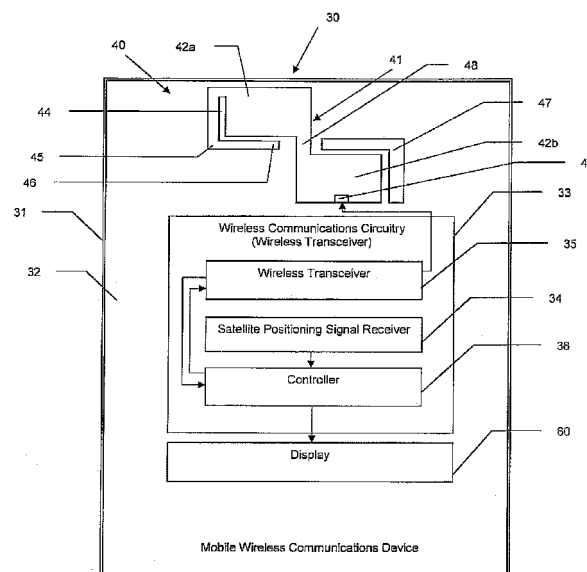


FIG. 2

EP 2 528 160 A1

Description

Technical Field

[0001] The present disclosure generally relates to the field of wireless communications systems, and, more particularly, to mobile wireless communications devices and related methods.

Background

[0002] Mobile wireless communications systems continue to grow in popularity and have become an integral part of both personal and business communications. For example, cellular telephones allow users to place and receive voice calls almost anywhere they travel. Moreover, as cellular telephone technology has increased, so too has the functionality of cellular devices and the different types of devices available to users. For example, many cellular devices now incorporate personal digital assistant (PDA) features such as calendars, address books, task lists, etc. Moreover, such multi-function devices may also allow users to wirelessly send and receive electronic mail (email) messages and access the Internet via a cellular network and/or a wireless local area network (WLAN), for example.

[0003] Even so, as the functionality of cellular communications devices continues to increase, so too does the demand for smaller devices which are easier and more convenient for users to carry. One challenge this poses for cellular device manufacturers is designing antennas that provide desired operating characteristics within the relatively limited amount of space available for antennas.

Brief Description of the Drawings

[0004] FIG. 1 is a top plan view of a mobile wireless communications device including an antenna assembly in accordance with one example embodiment.

[0005] FIG. 2 is a schematic block diagram of the device of FIG. 1.

[0006] FIG. 3 is a side schematic view of the substrate of the device of FIG. 1.

[0007] FIG. 4 is a graph of simulated S-parameters for the antenna assembly of FIG. 2.

[0008] FIGS. 5a-5c are graphs of simulated gain for the antenna assembly of FIG. 2 at a frequency of 3.2 GHz.

[0009] FIGS. 6a-6c are graphs of simulated gain for the antenna assembly of FIG. 2 at a frequency of 7.3 GHz.

[0010] FIG. 7 is a schematic block diagram of a device according to another example embodiment.

[0011] FIG. 8 is a schematic block diagram illustrating in more detail components that may be included in the mobile wireless communications device of FIG. 1.

Detailed Description

[0012] The present description is made with reference

to the accompanying drawings, in which various embodiments are shown. However, many different embodiments may be used, and thus the description should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete. Like numbers refer to like elements throughout, and prime notation is used to indicate similar elements or steps in alternative embodiments.

[0013] In accordance with one exemplary aspect, a mobile wireless communications device may include a portable housing, a substrate carried by the portable housing, and wireless communications circuitry carried by the substrate. The mobile wireless communications device may also include at least one antenna assembly carried by the substrate and coupled to the wireless communications circuitry. The at least one antenna assembly may include an electrically conductive base conductor having a first rectangular base portion and a second rectangular base portion offset therefrom. The first and second base portions may be coupled at respective diagonally opposing corners thereof and having an antenna feed defined on one of the first and second rectangular base portions. The at least one antenna assembly may include at least one electrically conductive arm extending along at least one side of one of the first and second rectangular base portions and spaced apart therefrom.

[0014] The at least one electrically conductive arm may include an L-shaped conductive arm. The at least one electrically conductive arm may be coupled to at least one of the first and second rectangular base portions, for example.

[0015] The at least one electrically conductive arm may also include at least one electrically floating conductive arm, for example. The at least one electrically conductive arm may include first and second electrically conductive arms adjacent the first and second rectangular base portions, respectively, for example. The at least one electrically conductive arm may extend along at least two sides of an adjacent one of the first and second rectangular base portions.

[0016] The substrate may include a dielectric layer and a conductive layer carried by the dielectric layer and define a ground plane, for example. The at least one antenna assembly may be above the ground plane. The at least one antenna assembly may include a plurality of spaced apart antenna assemblies.

[0017] A method aspect is directed to a method of making a mobile wireless communications device that may include a portable housing, a substrate carried by the portable housing, and wireless communications circuitry carried by the substrate. The method may include forming at least one antenna assembly on the substrate and coupled to the wireless communications circuitry. The antenna assembly may be formed by at least forming an electrically conductive base conductor comprising a first rectangular base portion and a second rectangular base

portion offset therefrom. The first and second base portions may be coupled at respective diagonally opposing corners thereof and may have an antenna feed defined on one of the first and second rectangular base portions, for example. Forming the at least one antenna assembly may also include forming at least one electrically conductive arm extending along at least one side of one of the first and second rectangular base portions and spaced apart therefrom.

[0018] Referring initially to FIGS. 1-3, a mobile wireless communications device **30** illustratively includes a housing **31** and a substrate **32**, for example, a printed circuit board (PCB) carried by the housing. The housing **31** has an upper portion and a lower portion. The substrate **32** may be a rigid PCB, or may be a flexible substrate or PCB, for example. In some embodiments wherein a PCB is used, the PCB may be replaced by or used in conjunction with a metal chassis or other substrate, as will be appreciated by those skilled in the art and described in further detail below. The substrate **32** includes a conductive layer **36** defining the ground plane (FIG. 3). The substrate **32** also includes a dielectric layer **37** carrying the conductive layer **36**. The substrate **32** may have additional layers, as will be appreciated by those skilled in the art. The dielectric layer **37** has a dielectric constant of 2.25 and dimensions of 40 mm x 100 mm. Of course, the dielectric layer **37** may have another value dielectric constant and other dimensions. The ground plane or conductive layer **36** is carried by one side of the dielectric layer **37** and has a smaller dimension than the dielectric layer, for example, 40 mm x 80 mm. Of course, the conductive layer **36** may have a different dimension, for example, a same dimension as the dielectric layer **37**.

[0019] Wireless communications circuitry **33** is carried by the portable housing **31**. The wireless communications circuitry **33** may include, for example, a wireless transceiver **35**. The wireless communications circuitry **33** may also include, in some embodiments, a satellite positioning signal receiver **34**. The satellite positioning signal receiver **34** may be a Global Positioning System (GPS) satellite receiver, for example. Of course, the mobile wireless communications device **30** may not include a satellite positioning receiver, or may include additional receivers and/or transmitters, for example, near-field communications (NFC) receivers and/or transmitters and wireless local area network receivers (e.g. 802.xx, WiFi, WiMax). The satellite positioning receiver **34** or other or additional receivers and/or transmitters may not be part of the wireless communications circuitry **33**, as will be appreciated by those skilled in the art.

[0020] The exemplary device **30** further illustratively includes a display **60** and a plurality of control keys including an "off hook" (i.e., initiate phone call) key **61**, an "on hook" (i.e., discontinue phone call) key **62**, a menu key **63**, and a return or escape key **64**. Operation of the various device components and input keys, etc., will be described further below with reference to FIG. 8.

[0021] The device **30** further illustratively includes an

antenna assembly **40** carried by the substrate **32** and coupled to the wireless communications circuitry **33**. The antenna assembly **40** is illustratively carried by an upper portion of the portable housing **31**. Of course, the antenna assembly may be carried elsewhere in the portable housing **31**. The antenna assembly **40** may also be positioned vertically with respect to the substrate **32**.

[0022] The antenna assembly **40** is a monopole antenna, and spaced above the ground plane or conductive layer **36**. The dielectric layer **37** carries the antenna assembly **40** on one side and the conductive layer **36** on an opposing side (FIG. 3). Alternatively, the antenna assembly **40** may be carried on the same side or surface of the dielectric layer **37** as the conductive layer **36**, for example. The antenna assembly **40** may be carried elsewhere by the substrate **32**. The antenna assembly **40** may be vertically or horizontally oriented with respect to the conductive layer **36**.

[0023] The antenna assembly **40** includes an electrically conductive base conductor **41**. The electrically conductive base conductor **41** includes a first rectangular base portion **42a** and a second rectangular base portion **42b** offset from the first rectangular base portion. The first and second base portions **42** are coupled at respective diagonally opposing corners thereof **48** and define the main radiating element.

[0024] An antenna feed point **43** is defined on the second rectangular base portion **42b**. Of course, the antenna feed point **43** may be defined on any one of the first and second rectangular base portions **42**. As will be appreciated by those skilled in the art, positioning or defining the feed point **43** along another portion of either of the first and second rectangular base portions **42** may result in polarization diversity or change in other antenna characteristics, such as, resonance frequency, bandwidth, and gain. For example, if the antenna assembly **40** is rotated 180 degrees and the antenna feed point **43** is defined on the first base portion **42a**, the polarization of the radiated field would be orthogonal compared to the radiated field of the antenna assembly without rotation.

[0025] A first L-shaped base conductor arm **45** is coupled to the first rectangular base portion **42a** at a corner diagonally opposing the corner coupled to the second rectangular base portion **42b**. The first L-shaped conductor **45** arm being coupled to the first rectangular base portion **42a** defines an L-shaped opening **44**. Illustratively, the first L-shaped base conductor arm **45** extends along two sides of the first rectangular base portion **42a**, and has an end **46** adjacent the coupled diagonally opposing corners **48**. The first L-shaped base conductor arm **45** advantageously may contribute to the increased bandwidth of the antenna assembly **40**, for example, from 3 GHz to 9 GHz. The first L-shaped base conductor arm **45** also may provide additional resonance to the antenna assembly **40**.

[0026] The antenna assembly **40** also illustratively includes a second L-shaped electrically conductive arm **47** that is adjacent the second rectangular base portion **42b**.

The second L-shaped electrically conductive arm **47** is electromagnetically coupled to the second rectangular base portion **42b**. The second L-shaped electrically conductive arm **47** is spaced apart from the second rectangular base portion **42b**, i.e. it is electrically floating. The second L-shaped electrically floating conductive arm **47** extends along a side of the second rectangular base portion **42b** from a corner thereof that is diagonally opposing the corner coupled to the first rectangular base conductor **42a**. The second L-shaped electrically floating conductive arm **47** extends along another side of the second rectangular base portion **42b** to adjacent the diagonally opposing coupled corners **48**. The second L-shaped electrically floating conductive arm **47** advantageously may also contribute to the increased bandwidth of the antenna assembly **40**, for example, from 3 GHz to 9 GHz. The second L-shaped electrically floating conductive arm **47** also may provide additional resonance to the antenna assembly **40**.

[0027] While the antenna assembly **40** illustratively includes the first L-shaped conductor arm **45** and the second L-shaped electrically floating conductive arm **47**, it will be appreciated by those skilled in the art that the antenna assembly may include either of the first and second L-shaped conductor arms. Moreover, each of the L-shaped conductor arms **45**, **47** may be positioned or oriented in another configuration.

[0028] The wireless communications circuitry **33** may also include a controller **38** or processor. The controller **38** may cooperate with the other components, for example, the antenna assembly **40**, the satellite positioning signal receiver **34**, and the wireless transceiver **33** to coordinate and control operations of the mobile wireless communications device **30**. Operations may include mobile voice and data operations, including email and Internet data.

[0029] The overall size of the antenna assembly **40** may be 12 mm x 10 mm, for example. The antenna assembly **40** may be other sizes. The antenna assembly **40** as will be appreciated by those skilled in the art, also has an omni-directional radiation pattern, increased efficiency, and increased constant gain for a relatively large bandwidth that may include the WiMax band, for example. In other words, the antenna assembly **40** advantageously provides nearly constant gain and increased radiation efficiency in the operating frequency band, for example. More particularly, the main lobe direction of the antenna assembly **40** is $\theta = 135$ degrees, and $\phi = 90$ degrees, while if the antenna assembly is rotated 180 degrees, as noted above, the main lobe direction is $\theta = 40$ degrees, and $\phi = 0$ degrees.

[0030] Referring now additionally to the graph **60** in FIG. 4, a simulated S parameter plot is illustrated. The simulated S parameter **61** of an antenna assembly similar to the antenna assembly **40** in FIG. 2 and described above is graphed versus frequency. The simulated S parameter **62** for an antenna assembly without both L-shaped conductive arms **45**, **47** is also illustrated. As il-

lustrated in the graph **60**, the L-shaped electrically conductive arms **45**, **47**, advantageously provide additional resonance to the antenna assembly **40** and may increase bandwidth at least by a factor of 7.

[0031] Referring now to the graphs **63**, **64**, and **65** in FIGS. 5a-5c, simulated radiation patterns for an antenna assembly similar to the antenna assembly **40** are illustrated. The graphs **63**, **64**, **65** illustrate the radiation patterns at the frequency of 3.2 GHz. Graph **63** illustrates the gain in the X-Y plane (FIG. 5a). Graph **64** illustrates the gain in the X-Z plane (FIG. 5b). Graph **65** illustrated the gain in the Y-Z plane (FIG. 5c). The Z axis is along the length of the substrate **32**, the X axis is along the width, and the Y axis is along the thickness. The gain is about 5.1 dB at the frequency of 3.2 GHz.

[0032] Referring now to the graphs **66**, **67**, and **68** in FIGS. 6a-6c, simulated radiation patterns for an antenna assembly similar to the antenna assembly **40** are illustrated. The graphs **66**, **67**, **68** illustrate the radiation patterns at the frequency of 7.3 GHz. Graph **66** illustrates the gain in the X-Y plane (FIG. 6a). Graph **67** illustrates the gain in the X-Z plane (FIG. 6b). Graph **68** illustrated the gain in the Y-Z plane (FIG. 6c). The Z axis is along the length of the substrate **32**, the X axis is along the width, and the Y axis is along the thickness. The gain is about 5.1 dB at the frequency of 7.3 GHz.

[0033] Moreover, based upon the relatively small size of the antenna assembly **40**, in other example embodiments, the antenna assembly **40** may be carried by a flexible substrate (not shown). The flexible substrate may be included with the substrate **32**, for example, for carrying other components or circuitry, for example, the display **60**, the wireless communications circuitry **33**, and the satellite positioning signal receiver **34**. The flexible substrate may advantageously allow for conforming of the antenna assembly **40** with the back of the portable housing **31**. The flexible substrate may include an adhesive layer (not shown), for example, a pressure sensitive adhesive, on an underside thereof for mounting. A copper layer (not shown) may be carried on a front side of the flexible substrate.

[0034] Referring now to FIG. 7, in another example embodiment, the mobile wireless communications device **30'** includes two antenna assemblies **40'**, **50'**. Each antenna assembly **40'**, **50'** is spaced apart and carried at the top portion of the portable housing **31'**. Of course, each antenna assembly **40'**, **50'** may be carried by a different portion of the portable housing **31'**. The first and second antenna assemblies **40'**, **50'** are illustratively similar to the antenna assembly **40** described above and illustrated in FIG. 2, for example. The second antenna assembly **50'** is also illustratively the same as the first antenna assembly **40'** in that it includes an electrically conductive base conductor **51'** including first and second rectangular base portions **52a'**, **52b'** coupled at respective diagonally opposing corners thereof **58'**, an antenna feed **53'** defined in the second rectangular base portion, and first and second L-shaped conductive arms **55'**, **57'**,

extending along the first and second rectangular base portions, respectively, and in the same configuration. Of course, the first and second antenna assemblies **40'**, **50'** may have different configurations and have more or less components relative to one another.

[0035] In addition to spatial diversity, as noted above, polarization diversity may also be accomplished by using the two antenna assemblies **40'**, **50'**. More particularly, polarization diversity may be achieved by rotating one of the first and second antenna assemblies **40'**, **50'** 180 degrees, and feeding that antenna assembly from the respective first rectangular base portion **42a'**, **52a'**. The relatively small size of each antenna assembly **40'**, **50'** may make it particularly advantageous in multiple-input and multiple-output (MIMO) systems, for example.

[0036] A method aspect is directed to a method of making a mobile wireless communications device **30** that may include a portable housing **31**, a substrate **32** carried by the portable housing, and wireless communications circuitry **33** carried by the substrate. The method includes forming an antenna assembly **40** on the substrate **32** and coupled to the wireless communications circuitry **33**. Forming the antenna assembly **40** includes forming an electrically conductive base conductor **41** comprising a first rectangular base portion **42a** and a second rectangular base portion **42b** offset therefrom. The first and second base portions **42** are coupled at respective diagonally opposing corners thereof and have an antenna feed **43** defined on one of the first and second base portions **42**. Forming the antenna assembly **40** also includes forming an electrically conductive arm **45**, **47** extending along at least one side of one of the first and second rectangular base portions **42** and spaced apart therefrom.

[0037] Example components of a mobile wireless communications device **1000** that may be used in accordance with the above-described embodiments are further described below with reference to FIG. 8. The device **1000** illustratively includes a housing **1200**, a keyboard or keypad **1400** and an output device **1600**. The output device shown is a display **1600**, which may comprise a full graphic LCD. Other types of output devices may alternatively be utilized. A processing device **1800** is contained within the housing **1200** and is coupled between the keypad **1400** and the display **1600**. The processing device **1800** controls the operation of the display **1600**, as well as the overall operation of the mobile device **1000**, in response to actuation of keys on the keypad **1400**.

[0038] The housing **1200** may be elongated vertically, or may take on other sizes and shapes (including clam-shell housing structures). The keypad may include a mode selection key, or other hardware or software for switching between text entry and telephony entry.

[0039] In addition to the processing device **1800**, other parts of the mobile device **1000** are shown schematically in FIG. 8. These include a communications subsystem **1001**; a short-range communications subsystem **1020**; the keypad **1400** and the display **1600**, along with other

input/output devices **1060**, **1080**, **1100** and **1120**; as well as memory devices **1160**, **1180** and various other device subsystems **1201**. The mobile device **1000** may comprise a two-way RF communications device having data and, optionally, voice communications capabilities. In addition, the mobile device **1000** may have the capability to communicate with other computer systems via the Internet.

[0040] Operating system software executed by the processing device **1800** is stored in a persistent store, such as the flash memory **1160**, but may be stored in other types of memory devices, such as a read only memory (ROM) or similar storage element. In addition, system software, specific device applications, or parts thereof, may be temporarily loaded into a volatile store, such as the random access memory (RAM) **1180**. Communications signals received by the mobile device may also be stored in the RAM **1180**.

[0041] The processing device **1800**, in addition to its operating system functions, enables execution of software applications **1300A-1300N** on the device **1000**. A predetermined set of applications that control basic device operations, such as data and voice communications **1300A** and **1300B**, may be installed on the device **1000** during manufacture. In addition, a personal information manager (PIM) application may be installed during manufacture. The PIM may be capable of organizing and managing data items, such as e-mail, calendar events, voice mails, appointments, and task items. The PIM application may also be capable of sending and receiving data items via a wireless network **1401**. The PIM data items may be seamlessly integrated, synchronized and updated via the wireless network **1401** with corresponding data items stored or associated with a host computer system.

[0042] Communication functions, including data and voice communications, are performed through the communications subsystem **1001**, and possibly through the short-range communications subsystem. The communications subsystem **1001** includes a receiver **1500**, a transmitter **1520**, and one or more antennas **1540** and **1560**. In addition, the communications subsystem **1001** also includes a processing module, such as a digital signal processor (DSP) **1580**, and local oscillators (LOs) **1601**. The specific design and implementation of the communications subsystem **1001** is dependent upon the communications network in which the mobile device **1000** is intended to operate. For example, a mobile device **1000** may include a communications subsystem **1001** designed to operate with the Mobitex™, Data TAC™ or General Packet Radio Service (GPRS) mobile data communications networks, and also designed to operate with any of a variety of voice communications networks, such as AMPS, TDMA, CDMA, WCDMA, PCS, GSM, EDGE, etc. Other types of data and voice networks, both separate and integrated, may also be utilized with the mobile device **1000**. The mobile device **1000** may also be compliant with other communications stand-

ards such as 3GSM, 3GPP, UMTS, 4G, etc.

[0043] Network access requirements vary depending upon the type of communication system. For example, in the Mobitex and DataTAC networks, mobile devices are registered on the network using a unique personal identification number or PIN associated with each device. In GPRS networks, however, network access is associated with a subscriber or user of a device. A GPRS device therefore typically involves use of a subscriber identity module, commonly referred to as a SIM card, in order to operate on a GPRS network.

[0044] When required network registration or activation procedures have been completed, the mobile device 1000 may send and receive communications signals over the communication network 1401. Signals received from the communications network 1401 by the antenna 1540 are routed to the receiver 1500, which provides for signal amplification, frequency down conversion, filtering, channel selection, etc., and may also provide analog to digital conversion. Analog-to-digital conversion of the received signal allows the DSP 1580 to perform more complex communications functions, such as demodulation and decoding. In a similar manner, signals to be transmitted to the network 1401 are processed (e.g. modulated and encoded) by the DSP 1580 and are then provided to the transmitter 1520 for digital to analog conversion, frequency up conversion, filtering, amplification and transmission to the communication network 1401 (or networks) via the antenna 1560.

[0045] In addition to processing communications signals, the DSP 1580 provides for control of the receiver 1500 and the transmitter 1520. For example, gains applied to communications signals in the receiver 1500 and transmitter 1520 may be adaptively controlled through automatic gain control algorithms implemented in the DSP 1580.

[0046] In a data communications mode, a received signal, such as a text message or web page download, is processed by the communications subsystem 1001 and is input to the processing device 1800. The received signal is then further processed by the processing device 1800 for an output to the display 1600, or alternatively to some other auxiliary I/O device 1060. A device may also be used to compose data items, such as e-mail messages, using the keypad 1400 and/or some other auxiliary I/O device 1060, such as a touchpad, a rocker switch, a thumb-wheel, or some other type of input device. The composed data items may then be transmitted over the communications network 1401 via the communications subsystem 1001.

[0047] In a voice communications mode, overall operation of the device is substantially similar to the data communications mode, except that received signals are output to a speaker 1100, and signals for transmission are generated by a microphone 1120. Alternative voice or audio I/O subsystems, such as a voice message recording subsystem, may also be implemented on the device 1000. In addition, the display 1600 may also be utilized

in voice communications mode, for example to display the identity of a calling party, the duration of a voice call, or other voice call related information.

[0048] The short-range communications subsystem enables communication between the mobile device 1000 and other proximate systems or devices, which need not necessarily be similar devices. For example, the short-range communications subsystem may include an infrared device and associated circuits and components, a Bluetooth™ communications module to provide for communication with similarly-enabled systems and devices, or a near field communications (NFC) sensor for communicating with a NFC device or NFC tag via NFC communications.

[0049] Many modifications and other embodiments of the invention will come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is understood that the invention is not to be limited to the specific embodiments disclosed, and that modifications and embodiments are intended to be included within the scope of the appended claims.

Claims

1. A mobile wireless communications device (30) comprising:
 - a portable housing (31);
 - a substrate (32) carried by said portable housing (31);
 - wireless communications circuitry (33) carried by said substrate (32); and
 - at least one an antenna assembly (40) carried by said substrate (32) and coupled to said wireless communications circuitry (33), and comprising
 - an electrically conductive base conductor (41) comprising a first rectangular base portion (42a) and a second rectangular base portion (42b) offset therefrom, said first and second base portions (42a, 42b) being coupled at respective diagonally opposing corners (48) thereof and having an antenna feed (43) defined on one of the first and second rectangular base portions (42a, 42b), and
 - at least one electrically conductive arm (47) extending along at least one side of one of said first and second rectangular base portions (42a, 42b) and spaced apart therefrom.
2. The mobile wireless communications device (30) according to Claim 1, wherein said at least one electrically conductive arm (47) comprises an L-shaped conductive arm (45).
3. The mobile wireless communications device (30) ac-

cording to Claim 1, wherein said at least one electrically conductive arm (47) is coupled to at least one of said first and second rectangular base portions (42a, 42b).

4. The mobile wireless communications device (30) according to Claim 1, wherein said at least one electrically conductive arm (47) comprises at least one electrically floating conductive arm (47).
5. The mobile wireless communications device (30) according to Claim 1, wherein said at least one electrically conductive arm (47) comprises first and second electrically conductive arms (47) adjacent said first and second rectangular base portions (42a, 42b), respectively.
6. The mobile wireless communications device (30) according to Claim 1, wherein said at least one electrically conductive arm (47) extends along at least two sides of an adjacent one of said first and second rectangular base portions (42a, 42b).
7. The mobile wireless communications device (30) according to Claim 1, wherein said substrate (32) comprises a dielectric layer (37) and a conductive layer (36) carried by said dielectric layer (37) and defining a ground plane.
8. The mobile wireless communications device (30) according to Claim 7, wherein said at least one antenna assembly (40) is above the ground plane.
9. The mobile wireless communications device (30) according to Claim 1, wherein said at least one antenna assembly (40) comprises a plurality of spaced apart antenna assemblies (40, 50).
10. A method of making a mobile wireless communications device (30) comprising a portable housing (31), a substrate (32) carried by the portable housing (31), and wireless communications circuitry (33) carried by the substrate (32), the method comprising:
 - forming at least one an antenna assembly (40) on the substrate (32) and coupled to the wireless communications circuitry (33) by at least forming an electrically conductive base conductor (41) comprising a first rectangular base portion (42a) and a second rectangular base portion (42b) offset therefrom, the first and second base portions (42a, 42b) being coupled at respective diagonally opposing corners (48) thereof and having an antenna feed (43) defined on one of the first and second rectangular base portions (42a, 42b), and
 - forming at least one electrically conductive arm (47) extending along at least one side of one of

the first and second rectangular base portions (42a, 42b) and spaced apart therefrom.

11. The method according to Claim 10, wherein forming the at least one electrically conductive arm (47) comprises forming an L-shaped conductive arm.
12. The method according to Claim 10, wherein forming the at least one electrically conductive arm (47) comprises forming the at least one electrically conductive arm (47) to be coupled to at least one of the first and second rectangular base portions (42a, 42b).
13. The method according to Claim 10, wherein forming the at least one electrically conductive arm (47) comprises forming at least one electrically floating conductive arm (47).
14. The method according to Claim 10, wherein forming the at least one electrically conductive arm (47) comprises forming first and second conductive arms (45, 47) adjacent the first and second rectangular base portions (42a, 42b), respectively.
15. The method according to Claim 10, wherein the forming at least one electrically conductive arm (47) comprises forming the at least one electrically conductive arm (47) to extend along at least two sides of an adjacent one of the first and second rectangular base portions (42a, 42b).

Amended claims in accordance with Rule 137(2) EPC.

1. A mobile wireless communications device (30) comprising:
 - a portable housing (31);
 - a substrate (32) carried by said portable housing (31) ;
 - wireless communications circuitry (33) carried by said substrate (32); and
 - at least one antenna assembly (40) carried by said substrate (32) and coupled to said wireless communications circuitry (33), and comprising
 - an electrically conductive base conductor (41) comprising a first rectangular base portion (42a) and a second rectangular base portion (42b) offset therefrom, said first and second base portions (42a, 42b) being coupled at respective diagonally opposing corners (48) thereof and having an antenna feed (43) defined on one of the first and second rectangular base portions (42a, 42b), and
 - at least one electrically conductive arm (47) extending along at least one side of one of said first and second rectangular base portions (42a, 42b) and

spaced apart therefrom.

2. The mobile wireless communications device (30) according to Claim 1, wherein said at least one electrically conductive arm (47) comprises an L-shaped conductive arm (45). 5

10

15

20

25

30

35

40

45

50

55

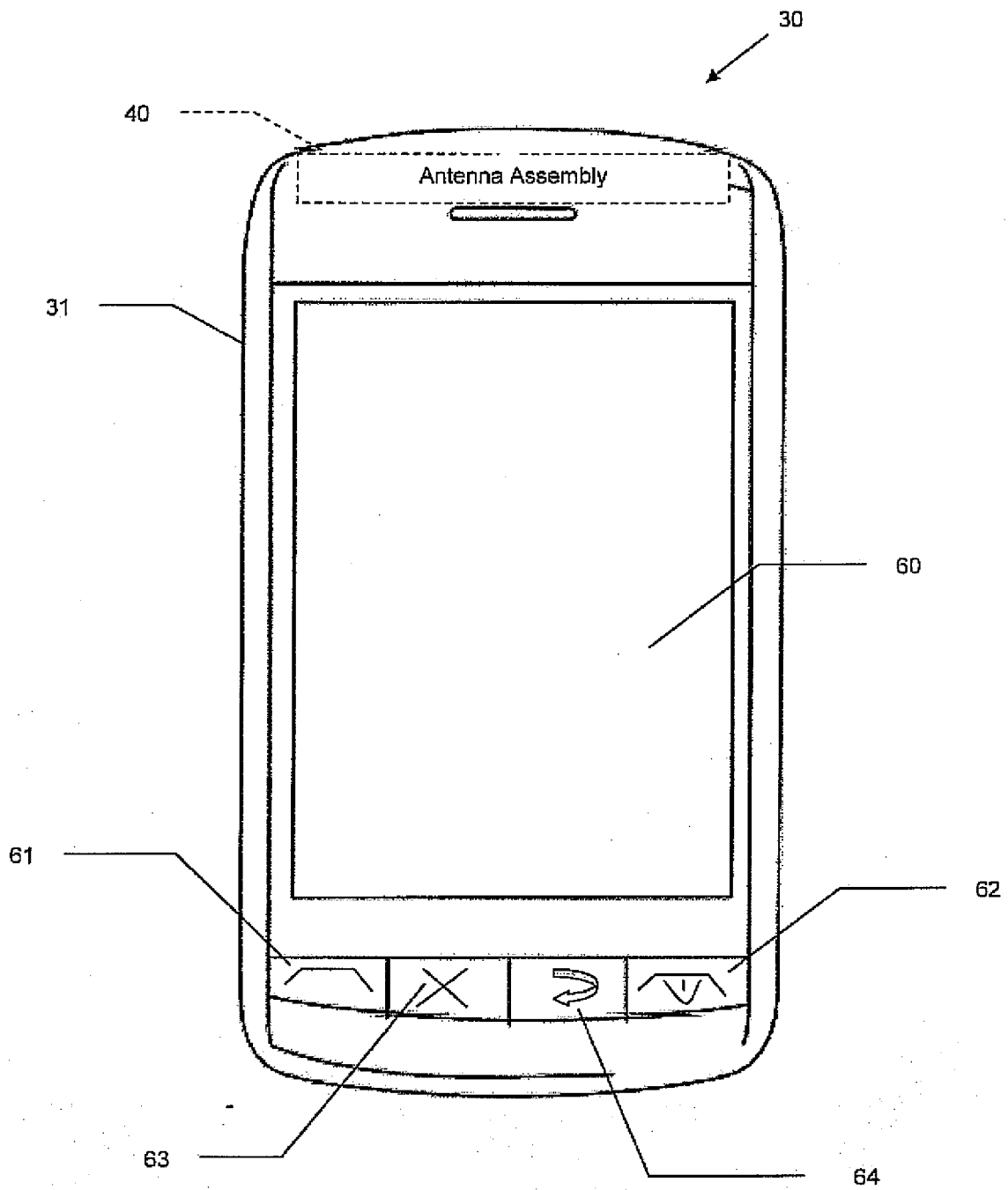


FIG. 1

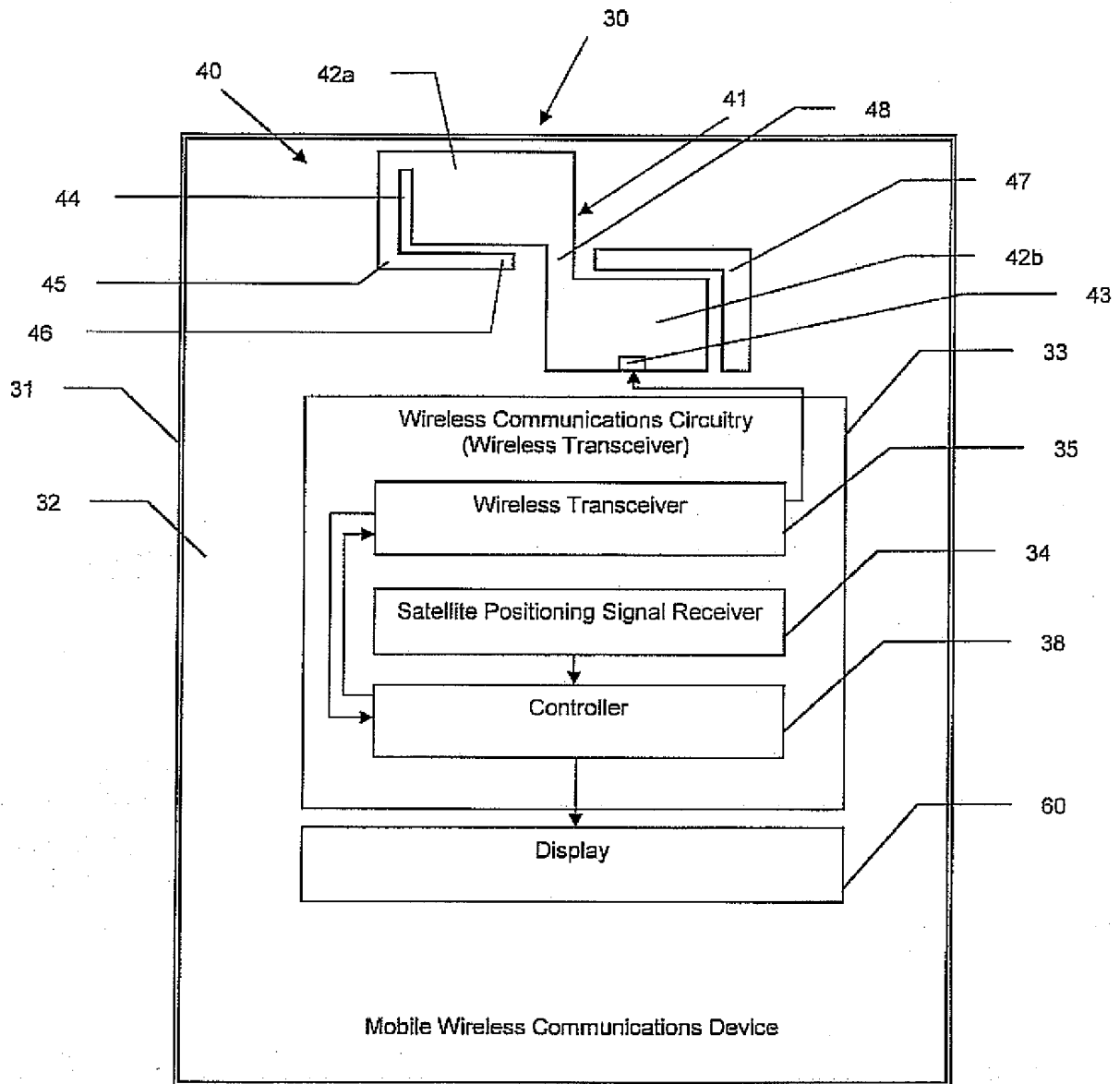


FIG. 2

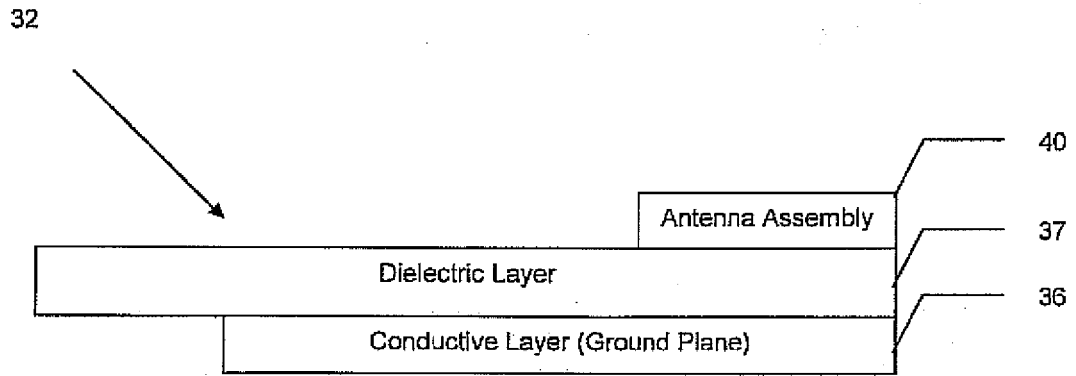


FIG. 3

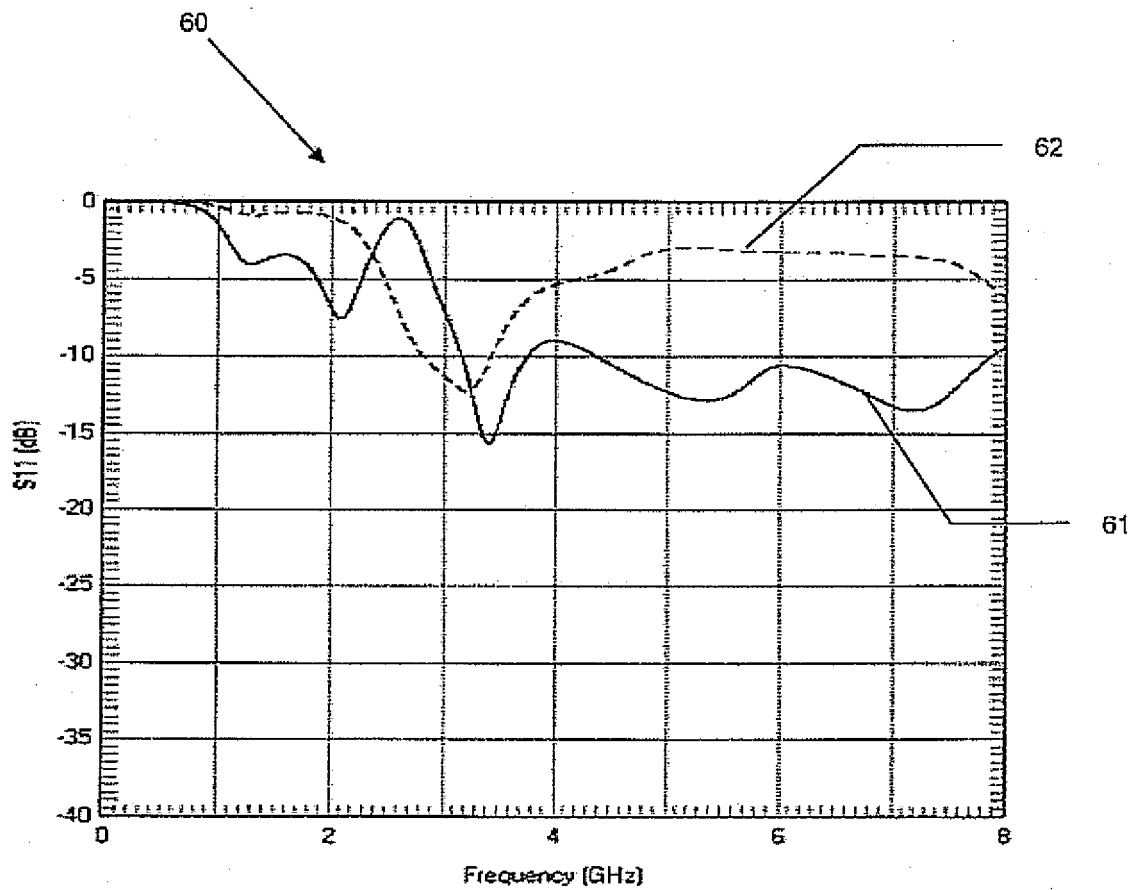


FIG. 4

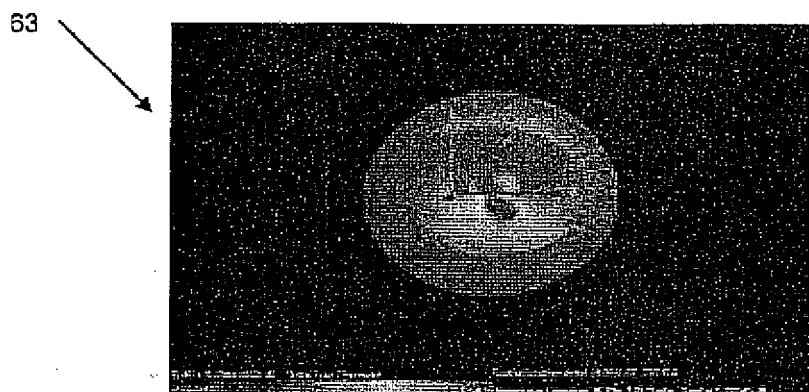


FIG. 5a

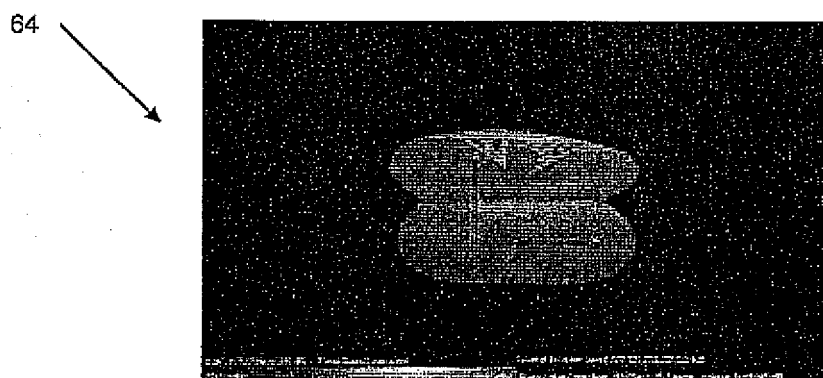


FIG. 5b

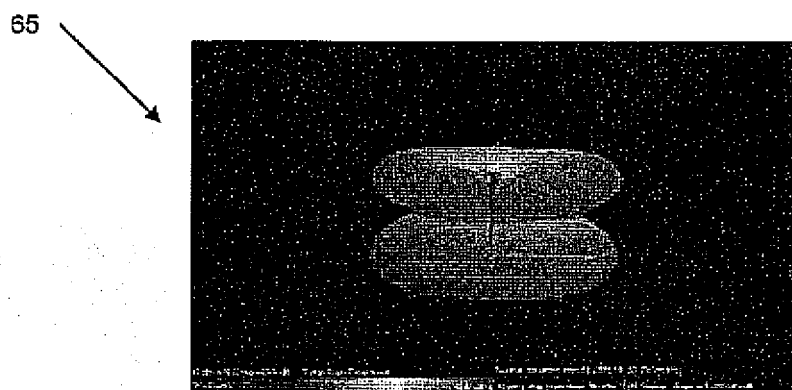


FIG. 5c

66

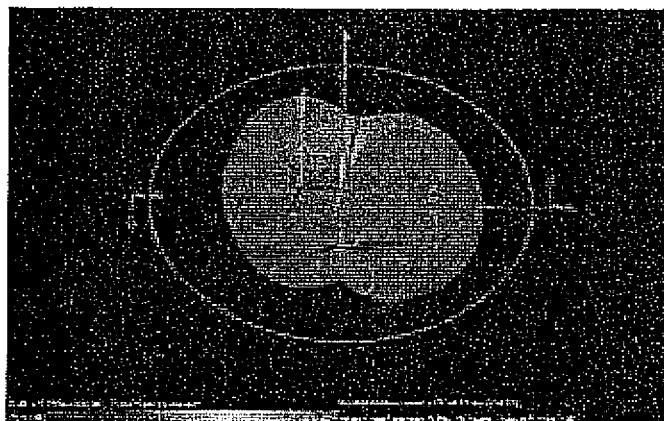


FIG. 6a

67

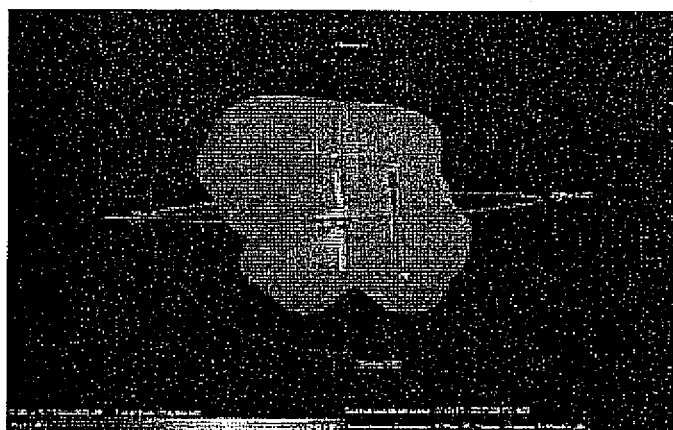


FIG. 6b

68

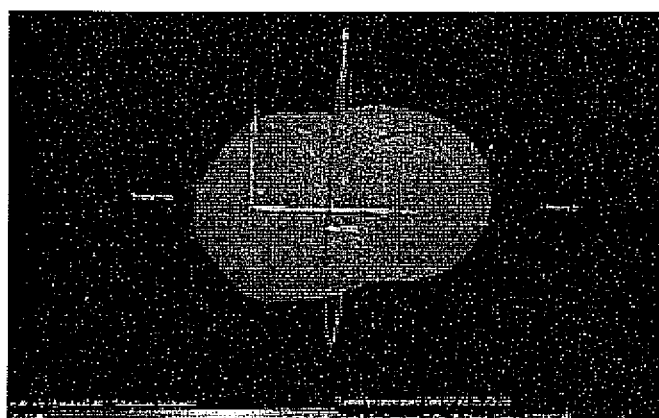


FIG. 6c

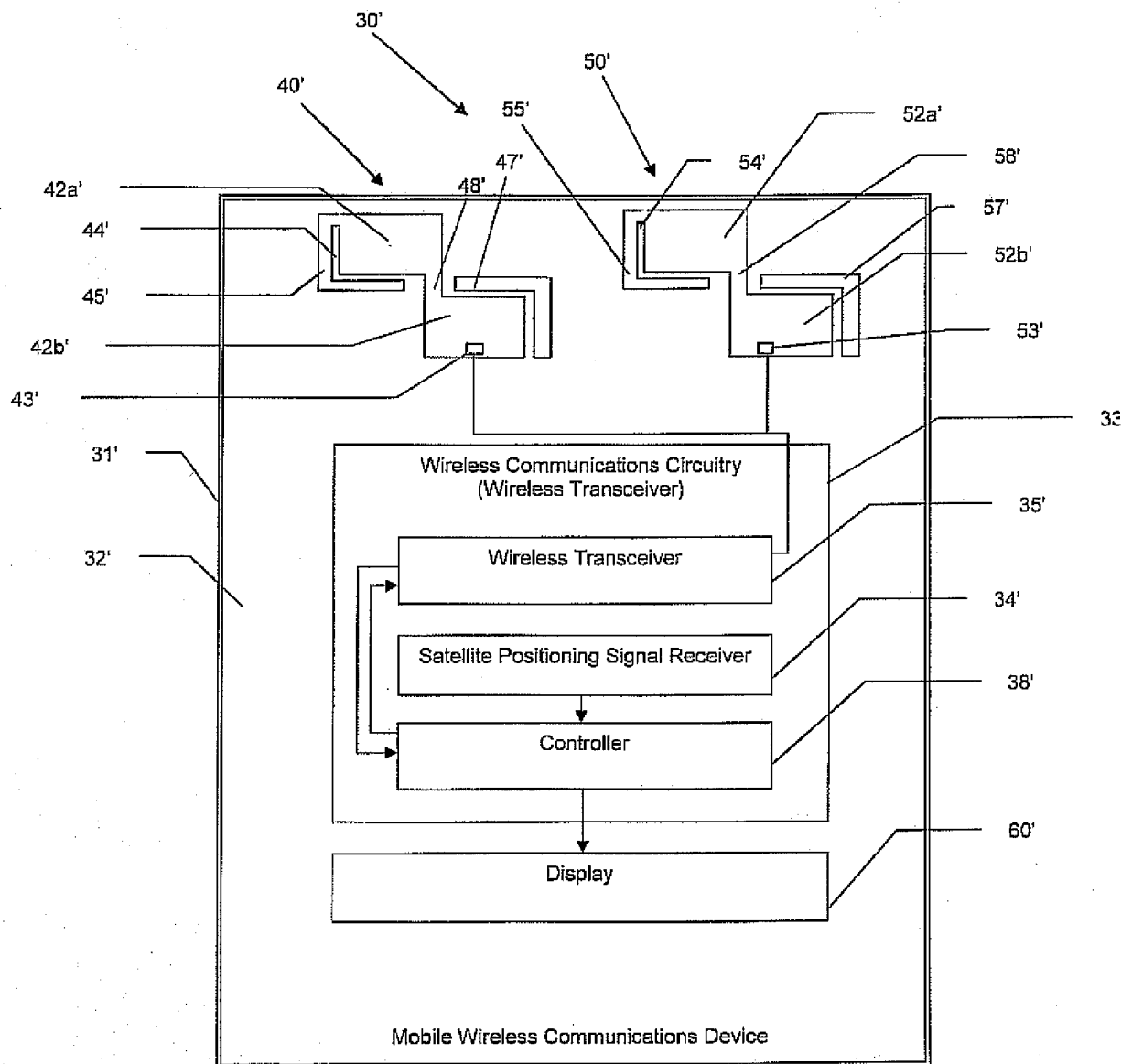


FIG. 7

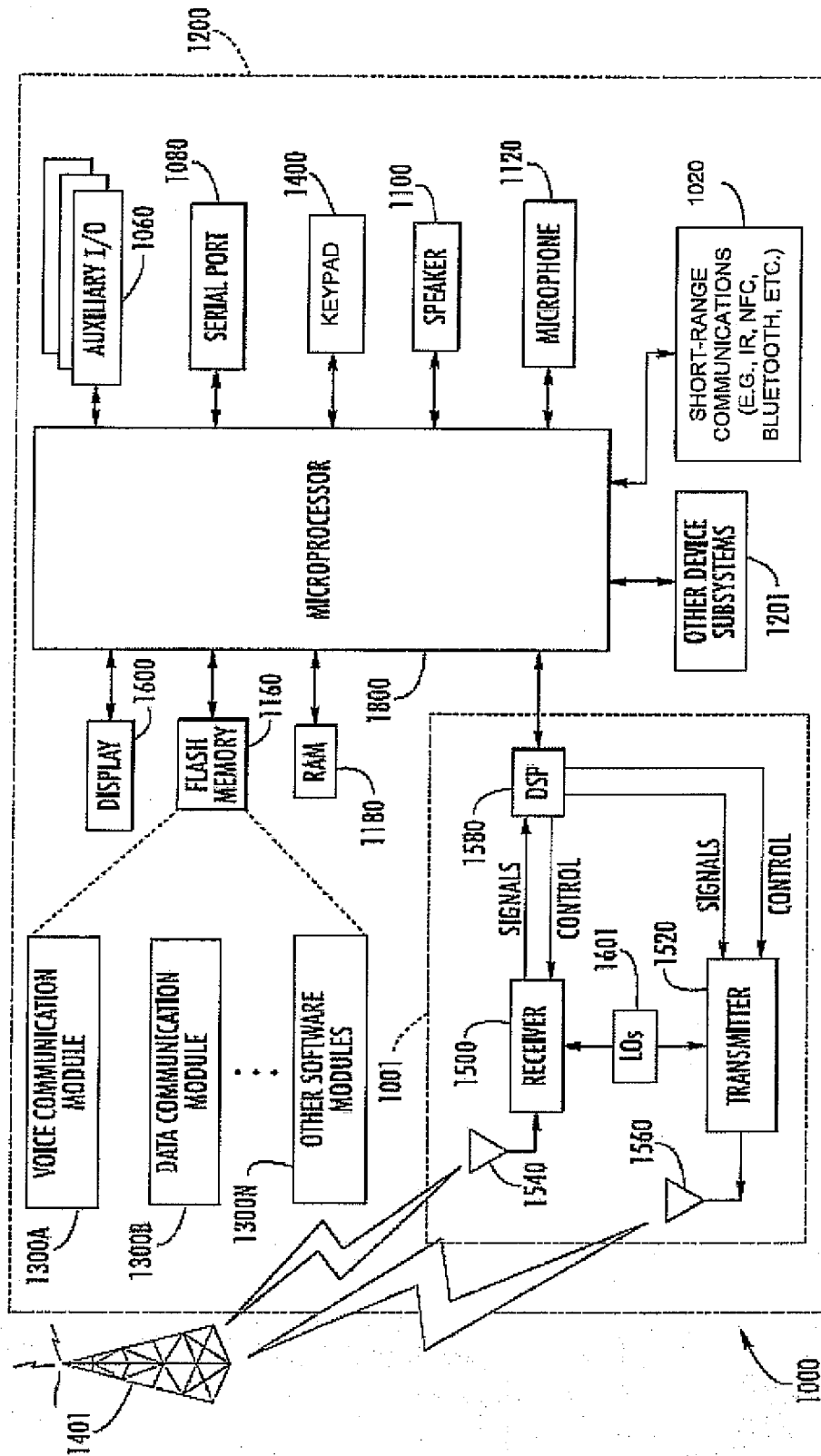


FIG. 8



EUROPEAN SEARCH REPORT

Application Number
EP 11 16 7349

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 10 093332 A (NIPPON ANTENNA KK) 10 April 1998 (1998-04-10) * page 3, paragraph 14 - paragraph 17 * * figures 3,4 * * abstract *	1-15	INV. H01Q1/24 H01Q9/04 H01Q21/28
X	US 7 161 540 B1 (LIU I-RU [TW]) 9 January 2007 (2007-01-09) * column 4, line 6 - column 6, line 36 * * figures 1A-2D * * abstract *	1-15	
A	JP 2003 158419 A (TDK CORP) 30 May 2003 (2003-05-30) * page 8, paragraph 61 * * figure 11 * * abstract *	1,10	
A	EP 1 094 542 A2 (MATSUSHITA ELECTRIC IND CO LTD [JP]) 25 April 2001 (2001-04-25) * column 12, line 54 - column 13, line 18 * * figure 5 * * abstract *	1-15	TECHNICAL FIELDS SEARCHED (IPC) H01Q
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 26 October 2011	Examiner von Walter, Sven-Uwe
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

 2
EPO FORM 1503 03.82 (P04C01)



EUROPEAN SEARCH REPORT

Application Number
EP 11 16 7349

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 10 093332 A (NIPPON ANTENNA KK) 10 April 1998 (1998-04-10) * page 3, paragraph 14 - paragraph 17 * * figures 3,4 * * abstract *	1-15	INV. H01Q1/24 H01Q9/04 H01Q21/28
X	US 7 161 540 B1 (LIU I-RU [TW]) 9 January 2007 (2007-01-09) * column 4, line 6 - column 6, line 36 * * figures 1A-2D * * abstract *	1-15	
A	JP 2003 158419 A (TDK CORP) 30 May 2003 (2003-05-30) * page 8, paragraph 61 * * figure 11 * * abstract *	1,10	
A	EP 1 094 542 A2 (MATSUSHITA ELECTRIC IND CO LTD [JP]) 25 April 2001 (2001-04-25) * column 12, line 54 - column 13, line 18 * * figure 5 * * abstract *	1-15	TECHNICAL FIELDS SEARCHED (IPC) H01Q
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 26 October 2011	Examiner von Walter, Sven-Uwe
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

2

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 11 16 7349

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

26-10-2011

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 10093332 A	10-04-1998	NONE	
US 7161540 B1	09-01-2007	JP 4664803 B2 JP 2007060609 A TW 1279031 B	06-04-2011 08-03-2007 11-04-2007
JP 2003158419 A	30-05-2003	NONE	
EP 1094542 A2	25-04-2001	CN 1308382 A US 6549169 B1	15-08-2001 15-04-2003