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[Continued on next page]

(54) Title: ADAPTIVELY OPTIMIZED METHOD AND SYSTEM OF PARASITIC ELEMENT SELECTION FOR SMART BEAM STEERING

(57) Abstract: A method at a device having an antenna and a plurality of parasitic elements, and the device, the method sensing a change in impedance of the antenna; selecting a subset of parasitic element options from a set of parasitic element options based on a stored table of impedances; if the subset of parasitic element options is greater than one, determining a channel quality measure for each parasitic element option within the subset of parasitic element options; and performing a beam steering action based on the change in antenna impedance and channel quality measure if determined, the beam steering action comprising selecting one or more of the plurality of parasitic elements to activate.

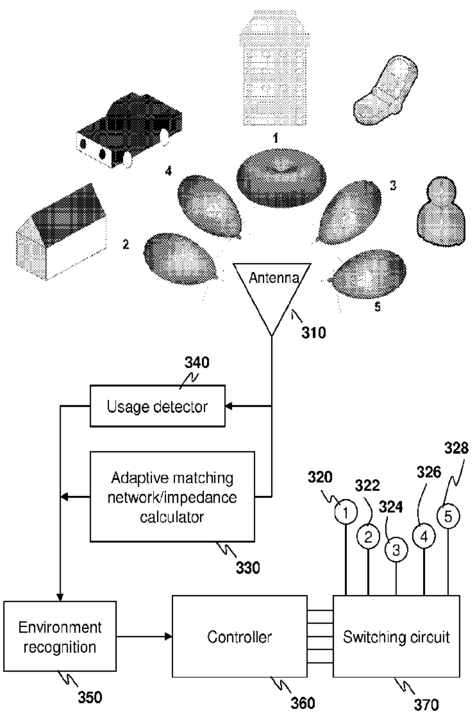

FIG. 3

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ADAPTIVELY OPTIMIZED METHOD AND SYSTEM OF PARASITIC ELEMENT SELECTION FOR SMART BEAM STEERING

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates to antennas and in particular to beam steering using parasitic elements within an antenna.

BACKGROUND

[0002] Antenna pattern beam steering is a technique proposed mainly to improve signal quality. The steering of the beam can be done through a number of techniques such as through the switching of antenna elements using diodes among other options. Beam steering techniques include manipulation of the antenna structure where the length of the antenna is changing. These techniques are usually used to steer a beam to follow the signal or to avoid interference, hence improving overall signal quality. These techniques are, however, difficult to implement mainly due to the steering mechanism that controls the hardware to achieve the desired beam direction.

[0003] Many techniques have been proposed to use the merit of the total received signal in determining the best hardware configuration that steers the beam in the desired direction. To do this, multiple measurements in real time are done in order to know the signal strength from the different directions. The multiple measurements are done in real time and therefore could introduce significant delays, especially if the user is in a fast changing environment.

[0004] Additionally, signal strength is not necessarily the best choice for the determination of best hardware configuration, especially if used alone. For example, signal strength is composed of the total desired signal as well as the noise signal combined. Therefore, the total signal strength alone may not be a fair indicator of the channel quality experienced by a specific beam pattern. Hence delayed and inaccurate decisions on the steering directions could be made.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The present disclosure will be better understood with reference to the drawings, in which:

Figure 1 is a block diagram of an exemplary antenna have selectable parasitic elements;

Figure 2 is a block diagram of an exemplary patch antenna have selectable parasitic elements;

Figure 3 is a block diagram of an exemplary architecture for the selection of parasitic elements;

Figure 4 is a process diagram showing an example method for selecting parasitic elements;

Figure 5 is a plot showing radiation from an antenna having antipodal parasitic elements selected;

Figure 6 is a plot of impedance values changing with an environment; and

Figure 7 is a block diagram of an exemplary mobile device capable of being used with the present methods and systems.

DETAILED DESCRIPTION OF THE DRAWINGS

[0006] The present disclosure provides a method at a device having an antenna and a plurality of parasitic elements, the method comprising: sensing a change in impedance of the antenna; selecting a subset of parasitic element options from a set of parasitic element options based on a stored table of impedances; if the subset of parasitic element options is greater than one, determining a channel quality measure for each parasitic element option within the subset of parasitic element options; and performing a beam steering action based on the change in antenna impedance and channel quality measure if determined, the beam steering action comprising selecting one or more of the plurality of parasitic elements to activate.

[0007] The present disclosure further provides a device comprising: a processor; an antenna; and a plurality of selectable parasitic elements, wherein the device is configured to sense a change in impedance of the antenna; select a subset of parasitic element options from a set of parasitic element options based on a stored table of impedances; if the subset of parasitic element options is greater than one, determine a channel quality measure; and perform a beam steering action based on the change in antenna impedance and channel quality measure if determined, the beam steering action comprising selecting one or more of the plurality of parasitic elements to activate.

[0008] The present disclosure can be utilized with any beam steering antenna. Two examples of beam steering antennas are shown below with regard to **Figures 1** and **2.** Such antennas are, for example, described with regard to US patent application no. 12/820,902, the contents of which are incorporated herein by reference. Beam steering, as used herein, includes use of a single radiating antenna which has its radiation pattern steered using passive parasitic elements.

[0009] Specifically, referring to **Figure 1,** the figure illustrates a block diagram of one embodiment of a beam steering antenna system **100** for a wireless device in accordance with various aspects set forth herein. In **Figure 1**, the system **100** can include a beam steering antenna **141**, and various elements as described below.

[0010] The beam steering antenna **141** can include a primary radiating element **150** with one or more secondary parasitic elements **151a** to **151e**. Parasitic elements, as used herein, may be conductive pieces that become electrically connected to the antenna, and hence be part of the antenna, depending on the termination of the parasitic elements. In this embodiment, the primary radiating element **150** is a dipole. Further, there are five reconfigurable parasitic elements, wherein each of the reconfigurable parasitic elements **151a** to **151e** is a dipole. In the embodiment of **Figure 1**, terminators **171a** to **171e** terminate parasitic elements **151a** to **151e** respectively. Terminators **171a** to **171e** may be any terminators, and include, for example, a ground, a reactive terminator or an open terminator.

[0011] In another embodiment, the primary radiating element and the reconfigurable parasitic elements are monopoles. It is important to recognize that the primary radiating element and any combination of the reconfigurable parasitic elements form the beam steering antenna, which can radiate with specific characteristics. Further, the primary radiating element and any combination of the reconfigurable parasitic elements can be electrically connected, electrically coupled, or both.

[0012] In one definition, a dipole antenna, is an omnidirectional radio antenna with a center-fed driven element, which can be made of, for instance, a simple copper wire. Further, in one definition, a monopole antenna is an omnidirectional antenna formed by replacing one half of a dipole antenna with a ground plane at a substantially perpendicular angle to the monopole, wherein the monopole can behave like a dipole if the ground plane is sufficiently large. The length of a radiating element such as a monopole can typically be as short as about one-quarter the wavelength of the desired resonant frequency. One skilled in the art will appreciate that the length of a radiating element of the present disclosure is not limited to one-quarter the wavelength of the desired resonant frequency, but other lengths may be chosen, such as one-half the wavelength of the desired resonant frequency. Similarly, the length of a radiating element such as a dipole can typically be as short as about one-half the wavelength of the desired resonant frequency.

[0013] The beam steering antenna **141** can direct an electromagnetic antenna-pattern beam **161a** to **161e** radiated from the beam steering antenna **141** to improve the quality of a transmitted signal, received signal, or both. The beam steering antenna **141** can adaptively steer the antenna-pattern beam **161a** to **161e** towards, for instance, a base station while traveling throughout the coverage area of the base station. For example, a controller, using switching circuit **147**, may select the parasitic element **151a**. In such configuration, the primary radiating element **150** and the parasitic element **151a** cooperatively transmit an antenna-pattern beam in the direction consistent with the antenna-pattern beam **161e**. In another example, a controller does not select any reconfigurable parasitic elements **151a** to **151e**.

In such configuration, the primary radiating element **150** provides an omnidirectional beam. In another example, a controller selects the reconfigurable parasitic elements **151a** and **151b**. In such configuration, the primary radiating element **150** and the reconfigurable parasitic elements **151a** and **151b** provide an antenna-pattern beam in the direction between the antenna-pattern beams **161e** and **161c**. Further, the beam steering antenna **141** can direct the antenna-pattern beam **161a** to **161e** away from a user of the associated wireless device to reduce the amount of electromagnetic energy absorbed by such user. Also, by directing the antenna-pattern beam **161a** to **161e** of the beam steering antenna **141** towards a receiving antenna such as at a base station can reduce the amount of interference received by other wireless devices.

[0014] By more effectively and efficiently receiving RF signals, radiating RF signals, or both, the wireless device using the beam steering antenna **141** can achieve better performance and lower power consumption. It is important to recognize any combination of reconfigurable parasitic elements can be used in conjunction with the primary radiating element. Further, any number of primary and reconfigurable parasitic elements can be used. For example, two primary radiating elements can be used to provide, for instance, polarization diversity. Further, six reconfigurable parasitic elements can be used in conjunction with the two primary radiating elements to cooperatively provide an antenna-pattern beam in a predetermined direction.

[0015] In **Figure 1**, the adaptive steering of the antenna-pattern beam can be performed using, for instance, switching elements associated with the switching circuit **147** to select parasitic elements **151a** and **151b** of the beam steering antenna **141**. The selected parasitic elements **151a** and **151b** and the primary radiating element **150** can cooperatively receive and radiate RF signals. For example, a plurality of reconfigurable parasitic elements **151a** and **151b** such as monopoles, dipoles, or both can be contiguously and uniformly distributed around a primary radiating element **150**. Such parasitic elements **151a** and **151b** can be adaptively switched to cooperatively work with the primary radiating element **150** to adaptively steer the antenna-pattern beam. It is important to recognize that the beam steering antenna configurations described by this disclosure may also provide polarization diversity, frequency diversity, multiband operation, broadband operation, or any combination thereof. Further, a person of ordinary skill in the art will recognize that there are many different antenna systems, structures, and configurations, which may support a beam steering function as described in this disclosure.

[0016] Further, another embodiment of a beam steering antenna is shown below with regard to **Figure 2**. **Figure 2** illustrates a block diagram of another embodiment of a beam steering antenna system **200** for a wireless device in accordance with various aspects set forth herein. **In Figure 2**, the system **200** can include a beam steering antenna **241**, as well as other components as described below.

[0017] The beam steering antenna **241** can include a primary radiating element **252** with one or more reconfigurable parasitic elements **253a** to **253e**. In this embodiment, the primary radiating element **252** is a patch antenna. Further, each of the reconfigurable parasitic elements **253a** to **253e** is a radiating strip or patch element.

[0018] A patch antenna typically is a miniaturized antenna radiating structure, such as a planar inverted-F antenna ("PIFA"). Patch antennas are popular for use in wireless devices due to their low profile, ability to conform to surface profiles, and unlimited shapes and sizes. Patch antenna polarization can be linear or elliptical, with a main polarization component parallel to the surface of the patch antenna. Operating characteristics of patch antennas are predominantly established by their shape and dimensions. A PIFA antenna design can include one or more slots in the antenna's radiating member. Selection of the position, shape, contour, and length of a slot depends on the design requirements of the particular patch antenna. The function of a slot in a patch antenna design includes physically partitioning the radiating member of a single-band patch antenna into a subset of radiating members for multiple-band operation, providing reactive loading to modify the resonant frequencies of a radiating member, and controlling the polarization characteristics of a multiple-band patch antenna. In addition to a slot, radiating members of a patch antenna can have stub members, usually consisting of a tab at the end of a radiating member. The function of a stub member includes providing reactive loading to modify the resonant frequencies of a radiating member.

[0019] The beam steering antenna **241** can direct an electromagnetic beam radiated from the beam steering antenna **241** to improve the quality of a transmitted signal, received signal, or both. For example, the beam steering antenna **241** can steer the antenna-pattern beam towards a base station while traveling throughout the coverage area of the base station. Further, the beam steering antenna **241** can direct the antenna-pattern beam away from a user of the associated wireless device to reduce the amount of electromagnetic energy absorbed by such user. Also, by directing the antenna-pattern beam of the beam steering antenna **241** towards a receiving antenna such as at a base station can reduce the amount of interference received by other wireless devices. By more effectively and efficiently receiving RF signals, radiating RF signals, or both, the wireless device using the beam steering antenna **241** can achieve lower power consumption.

[0020] In **Figure 2**, the steering of the antenna-pattern beam can be performed using, for instance, switching elements associated with the switching circuit **247** to select reconfigurable parasitic elements of the beam steering antenna **241**. The selected parasitic elements and the primary radiating element can cooperatively receive and radiate RF signals. For example, a plurality of radiating strip elements **253a** to **253e** can be adaptively switched to cooperatively work with the patch antenna **252** to steer the antenna-pattern beam. It is important to recognize that the aforementioned beam steering antenna configurations may also provide polarization diversity, frequency diversity, multiband operation, broadband operation, or any combination thereof.

[0021] An antenna, such as those described above with regard to **Figures 1** and **2,** could be utilized in a system in accordance with the present disclosure. For example, one exemplary system is described below with regard to **Figure 3**.

[0022] In accordance with the present disclosure, an optimized method for accurate antenna beam steering is provided, when needed, in real time, via adaptive switching of parasitic elements.

[0023] In the case that on-line signal quality measurements are needed, an optimized method is provided that gives an indication of the channel quality through measurements of the actual received power strength in the receive mode rather than total received signal strength, measured at baseband, which may include measurements of the noise levels as well.

[0024] In the case that on-line signal quality measurements are needed, an optimized method is provided that gives an indication of the channel quality measured at the antenna terminals through the amount of reflected power back into the radio using, for example, a directional coupler in the transmission mode.

[0025] Various channel quality indicators are described herein. In one embodiment, the desired signal strength channel quality indicator is extracted through a training sequence as provided below.

[0026] In accordance with the embodiment of **Figure 3** antenna **310** could be any antenna with beam steering capabilities. Examples of such an antenna are provided above with regard to **Figures 1** and **2**.

[0027] In the example of **Figure 3**, five parasitic elements are provided, namely parasitic elements **320, 322, 324, 326** and **328**. However, the present disclosure is not meant to be limited to any particular number or configuration of parasitic elements and more or less parasitic elements could be utilized depending on the implementation.

[0028] In the embodiment of **Figure 3**, parasitic elements **320** to **328** are designed based on their geometric dimensions and their distance and coupling to the main antenna **310**.

[0029] Antenna **310** is electrically physically connected to an adaptive matching network/impedance calculator block **330**. Block **330** can be used to calculate the exact input impedance value in real time for an assessment period. Further, the adaptive matching network can also be used to calculate input impedance and reduce mismatched loss after the parasitic element(s) have been chosen and the new beam steering antenna is formed.

[0030] Antenna **310** further provides an input to a usage detector block **340**. The usage detector block **340** can be used to determine the operating environment of the wireless device, which may be used to further adapt the antenna pattern beam of beam steering antenna **310**. The usage detector block **340** can receive a signal from the antenna **310** and can determine the operating environment of the mobile device by identifying a change in, for example, the received signal strength of beam steering antenna **310**, the direction alignment of the mobile device, the propagation characteristics of a received signal, the input impedance of the beam steering antenna **310**, or other information or a combination thereof.

[0031] For instance, usage detector block **340** can determine that a mobile device is placed against a user's head during a voice call using the call processing state of the mobile device, the directional alignment of the mobile device, a change in input impedance of the beam steering antenna **310**, among other factors, or combination thereof. For instance, usage to antenna **310** may use a sensor to indicate that the mobile device is in a substantially horizontal directional alignment consistent with the positioning of the wireless device by the user during a voice call. Each usage detector block **340** may also know the state of the wireless device such as the voice call state or data transmission state.

[0032] The outputs from usage detector block **340** and adaptive matching network/impedance calculator block **330** are provided to an environment recognition block **350**. Environment recognition block **350** use indicators to determine the operation or environment of the device. Such indicators may include inputs from accelerometers, including test results to indicate whether the device is vertical, horizontal, impedance values to provide whether the device is near the head of a user, among other indicators. The output from environment recognition block **350** is provided to a controller **360**. Controller **360** is used to identify the need for a beam steer to select parasitic elements.

[0033] Controller **360** can use the calculated impedance and environment factors to match a predefined and stored table of usage scenarios. Thus, a table or linked list or other storage mechanism on the device might be used to match impedance with usage scenarios to determine one or more parasitic elements to turn on. Controller **360** controls switching circuit **370** which then may turn off or on parasitic elements **320, 322, 324, 326** and **328**.

[0034] The beam steering is done, in one embodiment, in accordance with three main steps.

[0035] In a first step, the need to steer beam is identified or the need to change the beam patterns is identified through a change in the calculated real time impedance in conjunction with the usage sensors.

[0036] In a second step, once the need for a change and usage scenario have been identified, a set of eligible parasitic elements are selected through the control unit. This selection may utilize an indication of channel quality and such an indication of channel quality may use one or more of the desired signal strength, total signal strength, signal-to-noise ratio and channel capacity.

[0037] In a third step, once the choice of parasitic elements has been made by a controller, a new antenna composed of the main antenna plus selected parasitic elements used in the new antenna is created and the new antenna impedance can be re-calculated through the adaptive match circuit to measure the mismatched due to the new parasitic elements.

[0038] Reference is now made to **Figure 4**.

[0039] The process of **Figure 4** starts a block **410** and proceeds to block **412** in which an assessment period is determined. In one embodiment, the assessment period could be determined based on a test mode or activation mode on the mobile device.

[0040] The process then proceeds to block **414** and the input impedance is calculated. As indicated above, this may be done by the adaptive matching network/impedance calculator block **330** of **Figure 3**.

[0041] The process then proceeds to block **420** in which the mobile device may calculate a change in input impedance and determine whether the change in input impedance is larger than a tolerance. In one embodiment, the tolerance is predetermined and stored at the mobile device.

[0042] From block **420**, if the input impedance has no change or a change that is smaller than the tolerance, the process proceeds to block **422** in which the device waits for the next assessment period. In one embodiment, the process may be continuous and have no wait at block **422**, in which case the process proceeds back to block **414** immediately.

[0043] From block **420**, if the change in the input impedance is larger than the tolerance, the process proceeds to block **430** in which the impedance value is compared against an observation table.

[0044] Further, the process proceeds to block **432** in which the usage scenario and propagation environment are identified. This is done through, for example, usage detector block **340** and environment recognition block **350**.

[0045] The information from blocks **430** and **432** are provided to a controller such as controller **360** of **Figure 3** and the process proceeds to block **434** in which an eligible set of parasitic elements is selected. The selection at block **434** can use, for example, a table of values and a secondary table or linked list to make a final determination as to the set of eligible parasitic elements that could be utilized.

[0046] The process then proceeds from block **434** to block **440** in which a check is made to determine whether two elements provide the same impedance. If no, the process proceeds to block **450** in which the selected parasitic elements are coupled to steer the beam and the process then proceeds back to block **422** to wait for the next assessment.

[0047] Conversely, if two elements provide the same input impedance the process then proceeds to block **460** in which other factors are used to determine which parasitic element to utilize. Such other factors could use signal strength identifiers such as desired signal strength, noise level, signal-to-noise ratio, capacity, total power, among other factors. Based on the determination block **460**, parasitic elements are selected which are then provided to block **450** to couple selected parasitic elements to steer the beam. Further, the choice of other factors can change between assessment periods.

[0048] The channel quality at block **460** could be calculated by receiving signal samples, correlating the received signal samples with a known sequence to produce correlation values, and forming an estimate of desired power level based on the correlation values. Further the calculation may be done before or after analog to digital conversion.

[0049] Some scenarios that would result in the same impedance value for two parasitic elements have patterns that might be antipodal with respect to each other. For example, in the example of **Figure 3**, parasitic elements **322** and **328** could be antipodal to each other. In these scenarios, a measure of the channel quality indicator in both directions could be used as the second metric needed to decide on the choice of a parasitic element to couple to the antenna at block **460** in addition to the calculated impedance.

[0050] The process then continues to assess the impedance and reconfigure the antenna with parasitic elements as required.

[0051] Referring to **Figure 5**, **Figure 5** shows an illustration for the beam steering case for a dipole example. In particular, the beam steering case as shown by reference numeral **510** could be the use of the parasitic element **322** from **Figure 3**. Conversely, the beam steering case shown by reference numeral **520** could be the use of parasitic element **328** from the example of **Figure 3**. The two are opposite to each other and show that the beam steering is in opposite directions. In the example of **Figure 5**, the beam steering is shown based on the switching of the parasitic element from left to right or vise versa.

[0052] Referring to **Figure 6**, **Figure 6** shows a plot of sample impedance values changing with the environment around an antenna when the mobile device is in a voice position. The results show the measured input impedance of the beam steering antenna **310** over time for a user operating a wireless device in a voice call. The graphical representation in its entirety is referred to by **600**. The number of the discrete-time sample of the measured input impedance of the beam steering antenna **310** is shown on the abscissa **601**. The measured input impedance of the beam steering antenna **310** is shown on the ordinate **602**. The graph **603** shows the imaginary values of the measured input impedance of the beam steering antenna **310**. The graph **604** shows the real values of the measured input impedance of the beam steering antenna **310**.

[0053] In the simulation, the beam steering antenna **310** could be antenna **141** from **Figure 1,** and uses a half-wavelength dipole for the primary radiating element **150** and five half-wavelength dipoles for the reconfigurable parasitic elements **151a** to **151e**. Each of the five reconfigurable parasitic elements **151a** to **151e** are one tenth of a wavelength from the primary radiating element **150**. Further, the antenna gain of the primary radiating element **150** is 1.65 dB and the antenna gain of the primary radiating element coupled with one of the reconfigurable parasitic elements **151a** to **151e** is 4.99 dB. The simulation was performed at a frequency of 900 MHz.

[0054] Based on the above, various applications of the proposed mechanism are provided below. However, this is not meant to be exhaustive and other examples would be apparent to those in the art having regard to the present disclosure.

[0055] One application of the above may be to compensate for the presence of a user or an obstacle. Elements **322, 324, 326** or **328** could be selected based on the steering direction required to avoid the obstacle.

[0056] In a further usage, the selection of the parasitic element may be done to compensate for low scattering environment where omnidirectional patterns would be favored over a directional pattern. In such a case, parasitic element **320** from **Figure 3** could be selected.

[0057] In other embodiments, the choice of the parasitic element may be made to cancel interference. For example, the choice of the parasitic element may be done to mitigate interference from another mobile device or cell phone in the vicinity of the user's device.

[0058] In other embodiments, the selection of the parasitic element may be done to allow the beam to follow the best communication direction with a tower.

[0059] The antenna and elements describe above could be used with any device. If the antenna is used in a mobile device, one exemplary device is described below with regard to **Figure 7**.

[0060] Mobile device **700** is typically a two-way wireless communication device having voice and data communication capabilities. Mobile device **700**

generally has the capability to communicate with other computer systems on the Internet. Depending on the exact functionality provided, the mobile device may be referred to as a data messaging device, a two-way pager, a wireless e-mail device, a cellular telephone with data messaging capabilities, a wireless Internet appliance, a wireless device, a user equipment, or a data communication device, as examples.

[0061] Where mobile device **700** is enabled for two-way communication, it will incorporate a communication subsystem **711**, including both a receiver **712** and a transmitter **714**, as well as associated components such as one or more antenna elements **716** and **718,** such as those described above with regards to **Figure 1** to **3**, local oscillators (LOs) **713**, and a processing module such as a digital signal processor (DSP) **720**. As will be apparent to those skilled in the field of communications, the particular design of the communication subsystem **711** will be dependent upon the communication network in which the device is intended to operate. The radio frequency front end of communication subsystem **711** can be any of the embodiments described above.

[0062] Network access requirements will also vary depending upon the type of network **719**. In some networks network access is associated with a subscriber or user of mobile device **700**. A mobile device may require a removable user identity module (RUIM) or a subscriber identity module (SIM) card in order to operate on a CDMA network. The SIM/RUIM interface **744** is normally similar to a card-slot into which a SIM/RUIM card can be inserted and ejected. The SIM/RUIM card can have memory and hold many key configurations **751**, and other information **753** such as identification, and subscriber related information.

[0063] When required network registration or activation procedures have been completed, mobile device **700** may send and receive communication signals over the network **719**. As illustrated in **Figure 7**, network **719** can consist of multiple base stations communicating with the mobile device. For example, in a hybrid CDMA 1x EVDO system, a CDMA base station and an EVDO base station communicate with the mobile station and the mobile device is connected to both simultaneously. Other examples of network technologies and base stations would be apparent to those in the art.

[0064] Signals received by antenna **716** through communication network **719** are input to receiver **712**, which may perform such common receiver functions as signal amplification, frequency down conversion, filtering, channel selection and the like. A/D conversion of a received signal allows more complex communication functions such as demodulation and decoding to be performed in the DSP **720**. In a similar manner, signals to be transmitted are processed, including modulation and encoding for example, by DSP **720** and input to transmitter **714** for digital to analog conversion, frequency up conversion, filtering, amplification and transmission over the communication network **719** via antenna **718**. DSP **720** not only processes communication signals, but also provides for receiver and transmitter control. For example, the gains applied to communication signals in receiver **712** and transmitter **714** may be adaptively controlled through automatic gain control algorithms implemented in DSP **720**.

[0065] Mobile device **700** generally includes a processor **738** which controls the overall operation of the device. Communication functions, including data and voice communications, are performed through communication subsystem **711**. Processor **738** also interacts with further device subsystems such as the display **722**, flash memory **724**, random access memory (RAM) **726**, auxiliary input/output (I/O) subsystems **728**, serial port **730**, one or more keyboards or keypads **732**, speaker **734**, microphone **736**, other communication subsystem **740** such as a short-range communications subsystem and any other device subsystems generally designated as **742**. Serial port **730** could include a USB port or other port known to those in the art.

[0066] Some of the subsystems shown in **Figure 7** perform communication-related functions, whereas other subsystems may provide “resident” or on-device functions. Notably, some subsystems, such as keyboard **732** and display **722**, for example, may be used for both communication-related functions, such as entering a text message for transmission over a communication network, and device-resident functions such as a calculator or task list.

[0067] Operating system software used by the processor **738** may be stored in a persistent store such as flash memory **724**, which may instead be a read-only memory (ROM) or similar storage element (not shown). Those skilled in the art will appreciate that the operating system, specific device applications, or parts thereof, may be temporarily loaded into a volatile memory such as RAM **726**. Received communication signals may also be stored in RAM **726**.

[0068] As shown, flash memory **724** can be segregated into different areas for both computer programs **758** and program data storage **750**, **752**, **754** and **756**. These different storage types indicate that each program can allocate a portion of flash memory **724** for their own data storage requirements. Processor **738**, in addition to its operating system functions, may enable execution of software applications on the mobile device. A predetermined set of applications that control basic operations, including at least data and voice communication applications for example, will normally be installed on mobile device **700** during manufacturing. Other applications could be installed subsequently or dynamically.

[0069] Applications and software may be stored on any computer readable storage medium. The computer readable storage medium may be a tangible or in transitory/non-transitory medium such as optical (e.g., CD, DVD, etc.), magnetic (e.g., tape) or other memory known in the art.

[0070] One software application may be a personal information manager (PIM) application having the ability to organize and manage data items relating to the user of the mobile device such as, but not limited to, e-mail, calendar events, voice mails, appointments, and task items. Naturally, one or more memory stores would be available on the mobile device to facilitate storage of PIM data items. Such PIM application may have the ability to send and receive data items, via the wireless network **719**. In one embodiment, the

PIM data items are seamlessly integrated, synchronized and updated, via the wireless network **719**, with the mobile device user's corresponding data items stored or associated with a host computer system. Further applications may also be loaded onto the mobile device **700** through the network **719**, an auxiliary I/O subsystem **728**, serial port **730**, short-range communications subsystem **740** or any other suitable subsystem **742**, and installed by a user in the RAM **726** or a non-volatile store (not shown) for execution by the processor **738**. Such flexibility in application installation increases the functionality of the device and may provide enhanced on-device functions, communication-related functions, or both. For example, secure communication applications may enable electronic commerce functions and other such financial transactions to be performed using the mobile device **700**.

[0071] In a data communication mode, a received signal such as a text message or web page download will be processed by the communication subsystem **711** and input to the processor **738**, which may further process the received signal for output to the display **722**, or alternatively to an auxiliary I/O device **728**.

[0072] A user of mobile device **700** may also compose data items such as email messages for example, using the keyboard **732**, which may be a complete alphanumeric keyboard or telephone-type keypad, among others, in conjunction with the display **722** and possibly an auxiliary I/O device **728**. Such composed items may then be transmitted over a communication network through the communication subsystem **711**.

[0073] For voice communications, overall operation of mobile device **700** is similar, except that received signals would typically be output to a speaker **734** and signals for transmission would be generated by a microphone **736**. Alternative voice or audio I/O subsystems, such as a voice message recording subsystem, may also be implemented on mobile device **700**. Although voice or audio signal output is preferably accomplished primarily through the speaker **734**, display **722** may also be used to provide an indication of the identity of a calling party, the duration of a voice call, or other voice call related information for example.

[0074] Serial port **730** in **Figure 7** would normally be implemented in a personal digital assistant (PDA)-type mobile device for which synchronization with a user's desktop computer (not shown) may be desirable, but is an optional device component. Such a port **730** would enable a user to set preferences through an external device or software application and would extend the capabilities of mobile device **700** by providing for information or software downloads to mobile device **700** other than through a wireless communication network. The alternate download path may for example be used to load an encryption key onto the device through a direct and thus reliable and trusted connection to thereby enable secure device communication. As will be appreciated by those skilled in the art, serial port **730** can further be used to connect the mobile device to a computer to act as a modem.

[0075] Other communications subsystems **740**, such as a short-range communications subsystem, is a further optional component which may provide for communication between mobile device **700** and different systems or devices, which need not necessarily be similar devices. For example, the subsystem **740** may include an infrared device and associated circuits and components or a Bluetooth™ communication module to provide for communication with similarly enabled systems and devices.

[0076] The embodiments described herein are examples of structures, systems or methods having elements corresponding to elements of the techniques of this application. This written description may enable those skilled in the art to make and use embodiments having alternative elements that likewise correspond to the elements of the techniques of this application. The intended scope of the techniques of this application thus includes other structures, systems or methods that do not differ from the techniques of this application as described herein, and further includes other structures, systems or methods with insubstantial differences from the techniques of this application as described herein.

CLAIMS

1. A method at a device having an antenna and a plurality of parasitic elements, the method comprising:

sensing a change in impedance of the antenna;

selecting a subset of parasitic element options from a set of parasitic element options based on a stored table of impedances;

if the subset of parasitic element options is greater than one, determining a channel quality measure for each parasitic element option within the subset of parasitic element options; and

performing a beam steering action based on the change in antenna impedance and channel quality measure if determined, the beam steering action comprising selecting one or more of the plurality of parasitic elements to activate.

2. The method of claim 1, wherein the beam steering action compares the antenna impedance with a usage scenario to select at least one candidate subset of parasitic element options.

3. The method of claim 2, wherein the antenna impedance and usage scenarios are pre-stored in the table at the device.

4. The method of claim 3, wherein the table stores pre-calculated impedance values that describe the usage scenario of the device.

5. The method of claim 2, wherein, if more than one subset of parasitic element options are selected, utilizing the channel quality measures to choose between the subsets of parasitic element options selected.

6. The method of claim 5, wherein the channel quality measure is at least one of: a desired power level; a signal to noise ratio; a capacity; and a total power measured at baseband in the receive mode.

7. The method of claim 5, wherein the channel quality measure is determined through the sensing of the reflected power measured at terminals of the antenna in a transmission mode.

8. The method of claim 7, wherein the channel quality measure is performed at the beam steering antenna terminals in the transmission mode.

9. The method of claim 5, wherein a choice of the channel quality measure can change.

10. The method of claim 9, wherein the channel quality measure comprises:

receiving signal samples;

correlating the received signal samples with a known sequence to produce correlation values; and

forming an estimate of desired power level based on the correlation values.

11. The method of claim 10, wherein the channel quality measure is performed before analog to digital conversion.

12. The method of claim 10, wherein the channel quality measure is performed after analog to digital conversion.

13. The method of claim 1, wherein the method is repeated after an assessment period has expired.

14. The method of claim 1, wherein the impedance is calculated through an adaptive matching circuit.

15. The method of claim 14, further comprising, after the performing the beam steering, the antenna plus selected at least one parasitic element impedance is recalculated through an adaptive matching circuit where the

adaptive matching circuit is retuned to match the antenna plus selected at least one parasitic element.

16. The method of claim 2, wherein the usage scenario is calculated through a usage detector and environment detector circuit.

17. A device comprising:

a processor;

an antenna; and

a plurality of selectable parasitic elements,

wherein the device is configured to perform the method of any one of claims 1 to 16.

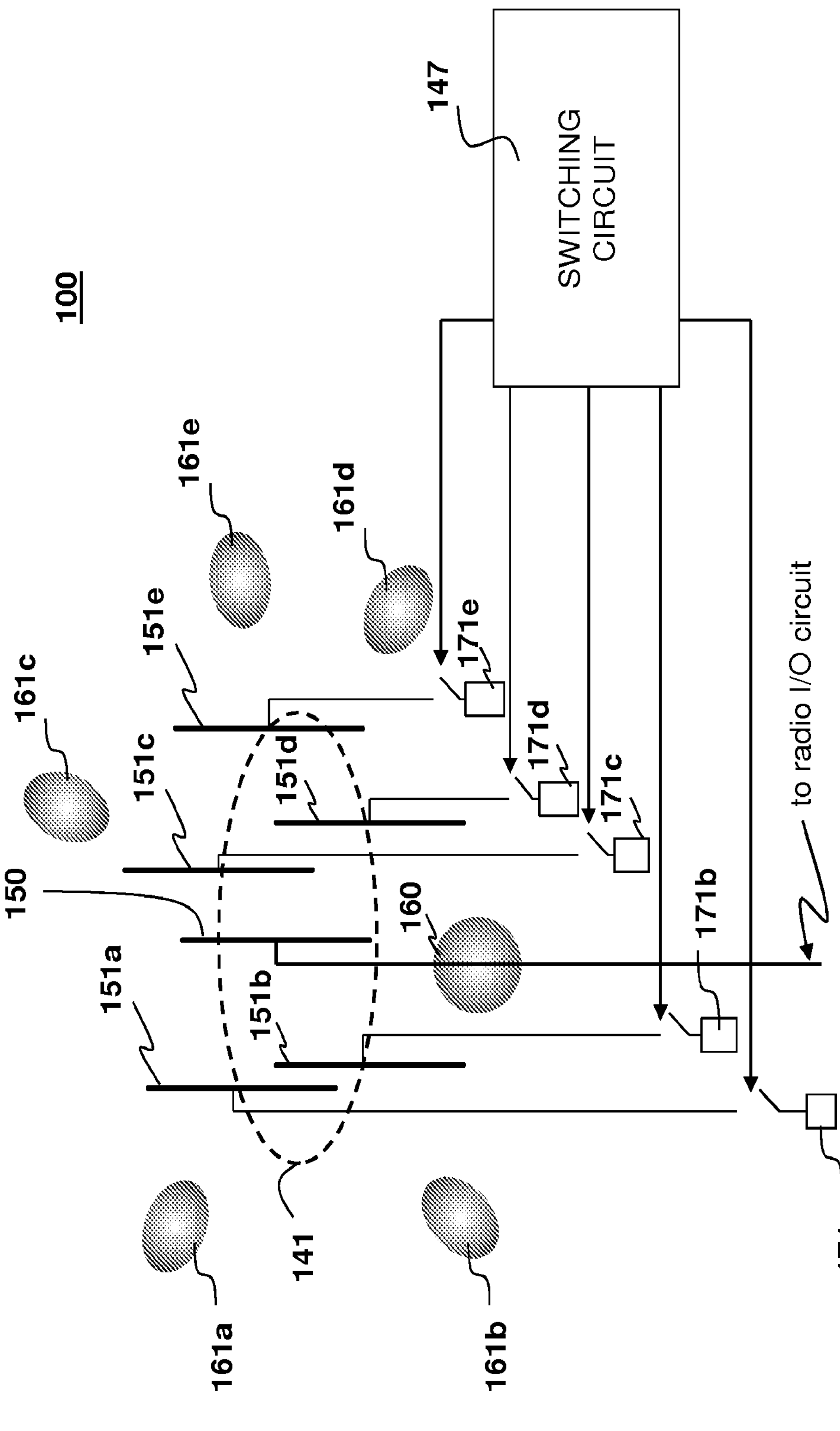
100
147
SWITCHING CIRCUIT
161e
161d
161c
151e
171e
151c
151d
171d
171c
150
160
151a
151b
171b
to radio I/O circuit
141
161a
161b
171a

FIG. 1

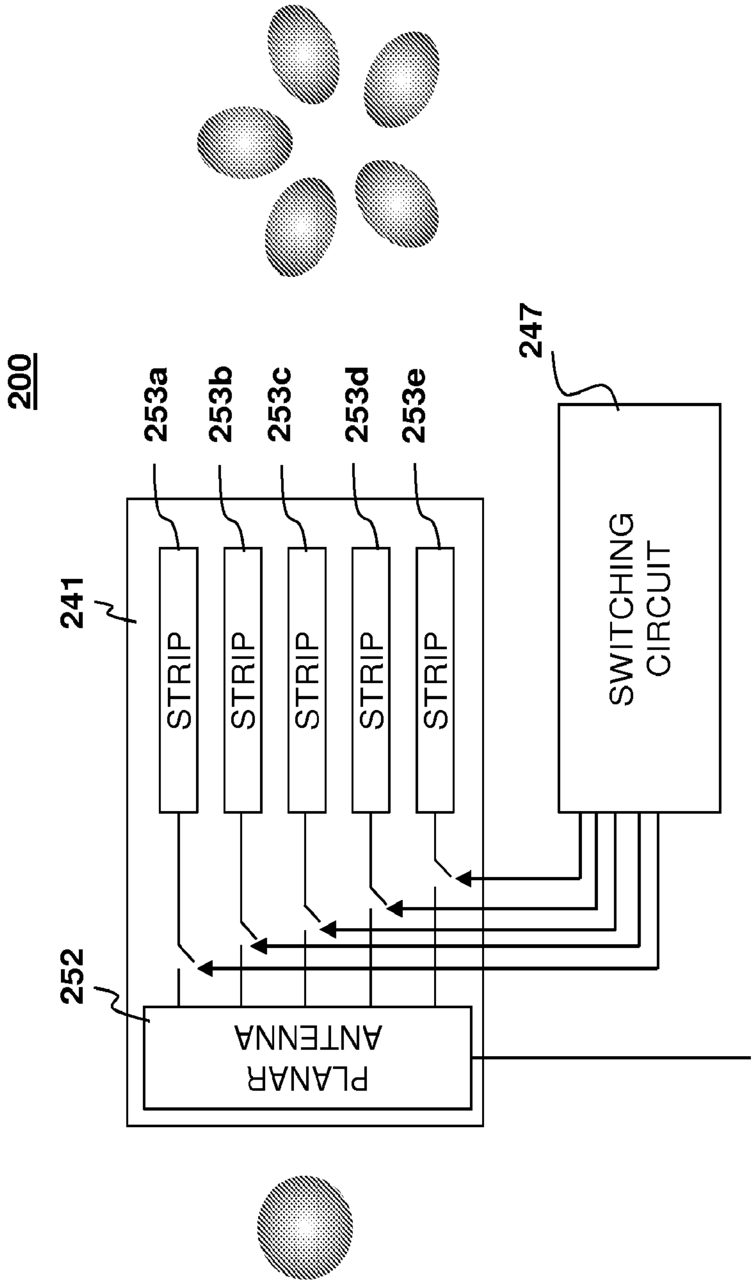
200
253a
253b
253c
253d
253e
247
241
STRIP
STRIP
STRIP
STRIP
STRIP
SWITCHING CIRCUIT
252
PLANAR ANTENNA

FIG. 2

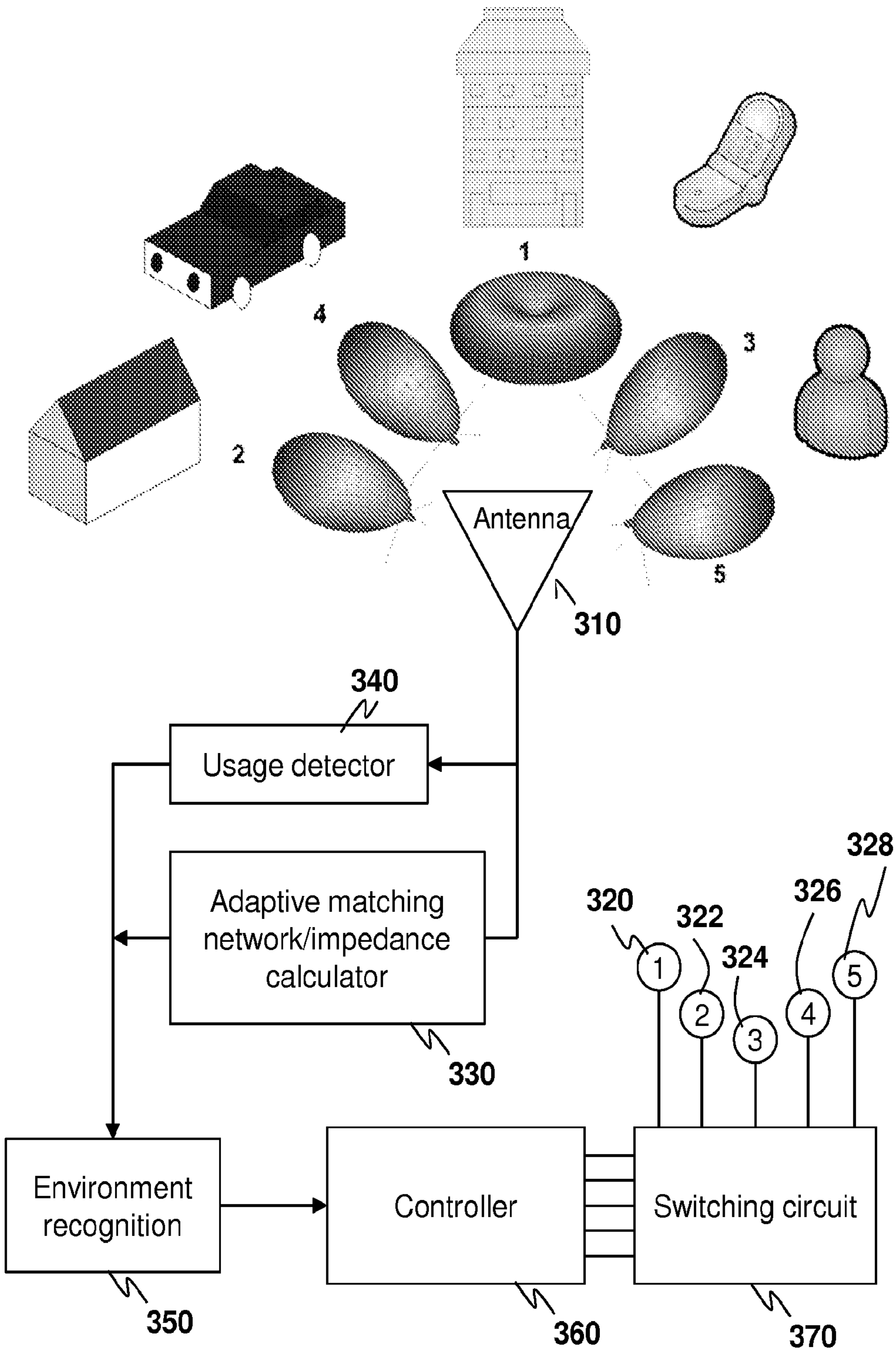
1
4
3
2
Antenna
5
310
340
Usage detector
Adaptive matching network/impedance calculator
330
328
320
322
324
326
1
2
3
4
5
Environment recognition
Controller
Switching circuit
350
360
370

FIG. 3

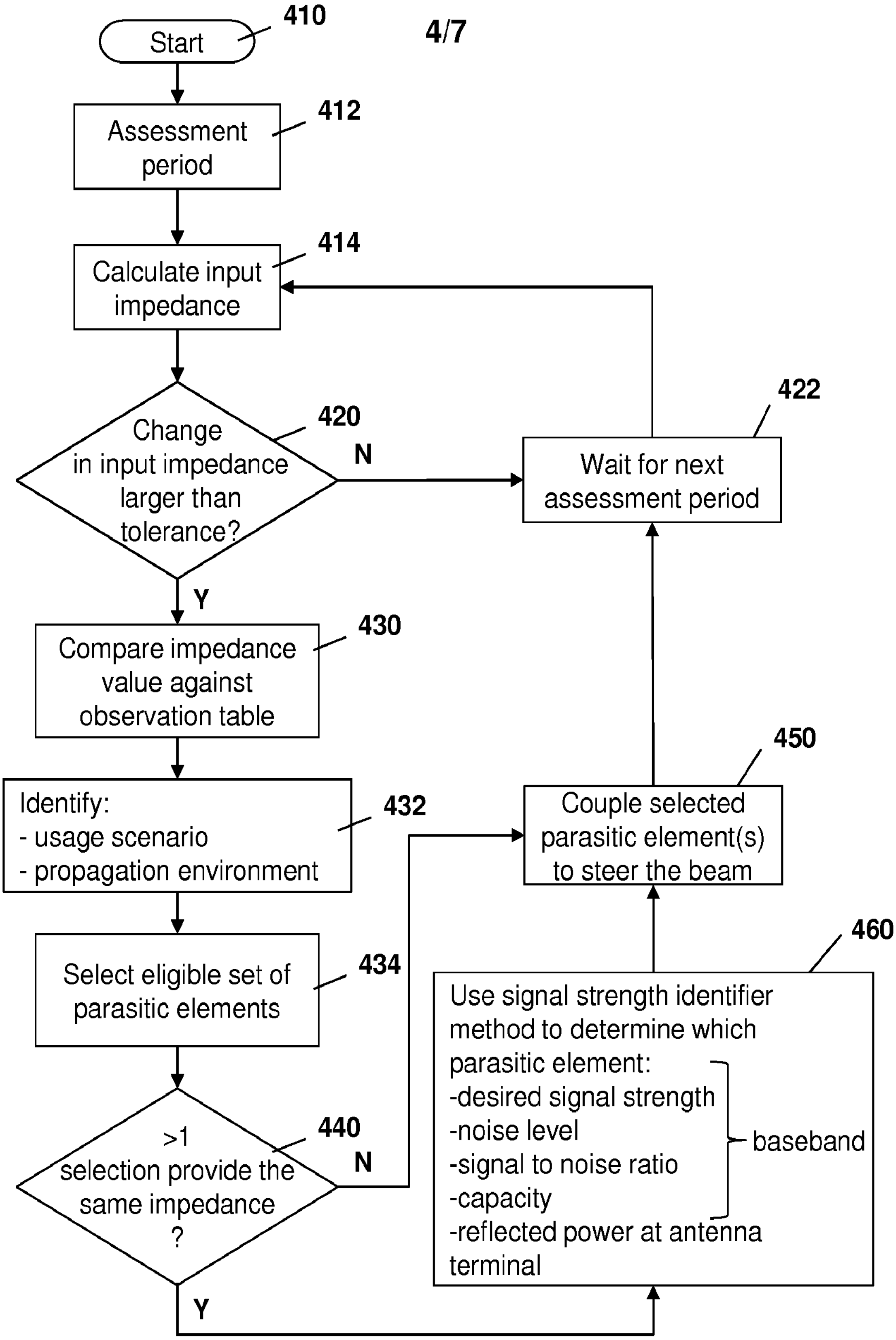
Start
410
Assessment period
412
Calculate input impedance
414
Change in input impedance larger than tolerance?
420
N
Y
Wait for next assessment period
422
Compare impedance value against observation table
430
Identify:
- usage scenario
- propagation environment
432
Select eligible set of parasitic elements
434
>1 selection provide the same impedance ?
440
N
Y
Couple selected parasitic element(s) to steer the beam
450
Use signal strength identifier method to determine which parasitic element:
-desired signal strength
-noise level
-signal to noise ratio
-capacity
-reflected power at antenna terminal
baseband
460

FIG. 4

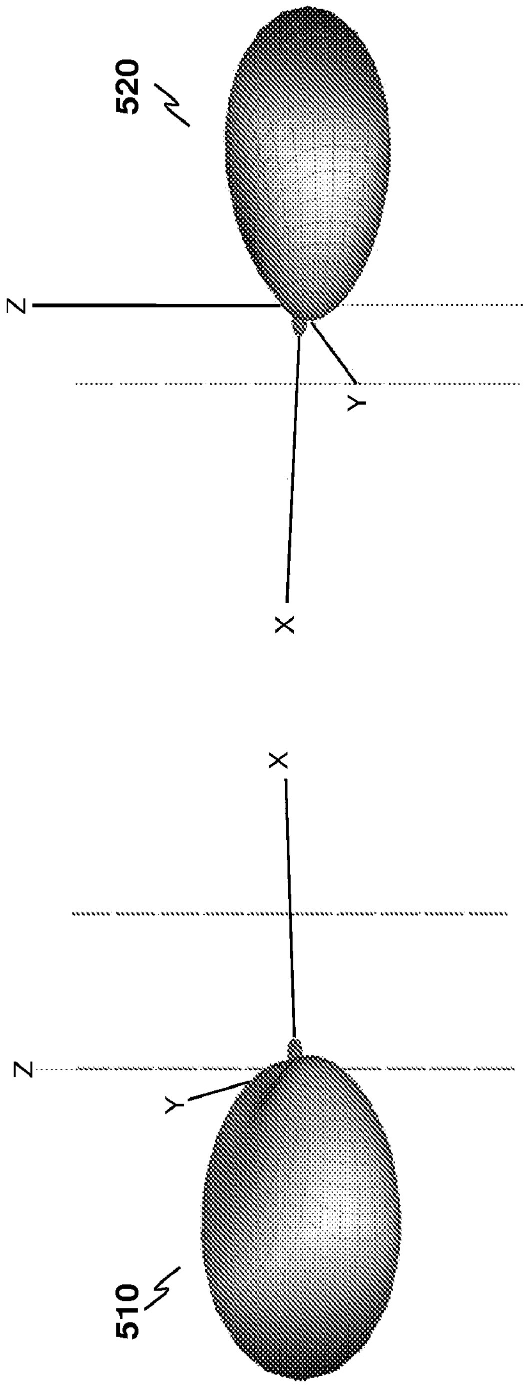

FIG. 5

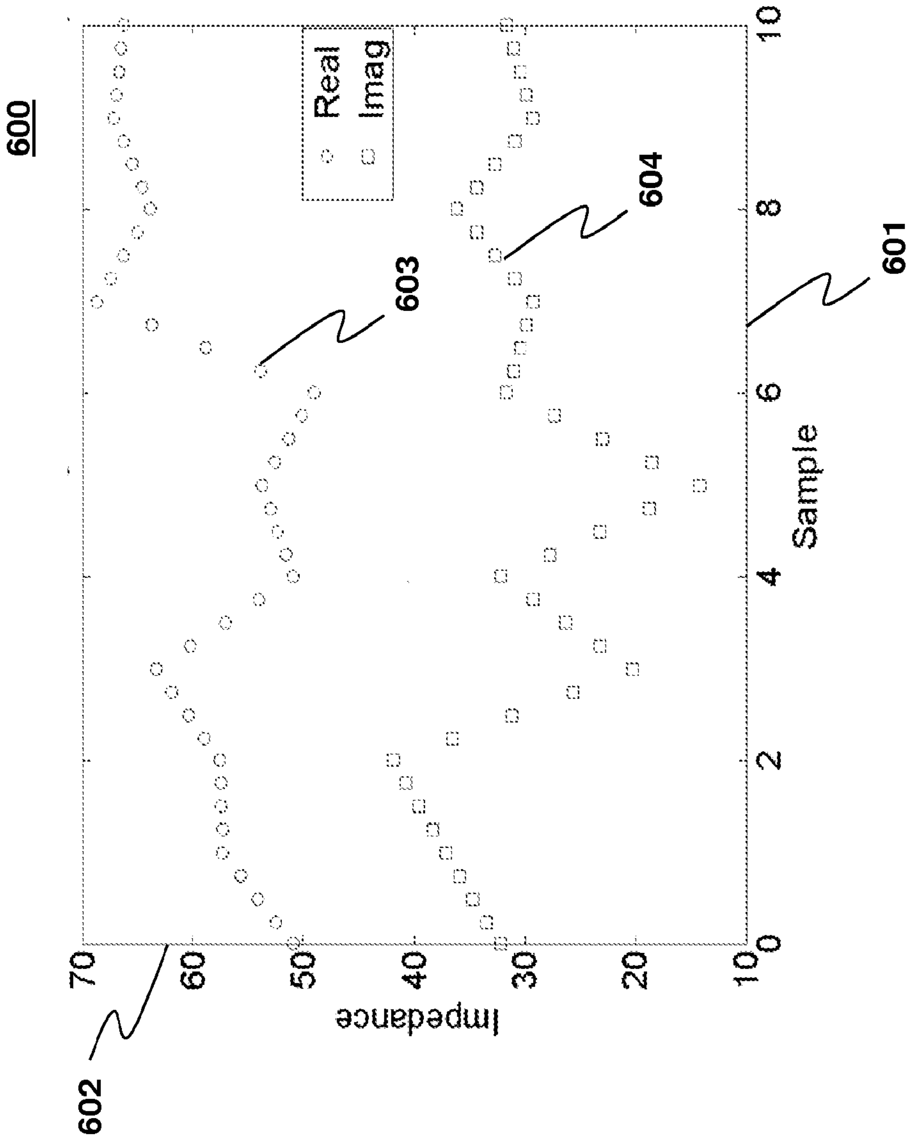
600
Real
Imag
Impedance
Sample
70
60
50
40
30
20
10
0
2
4
6
8
10
601
602
603
604

FIG. 6

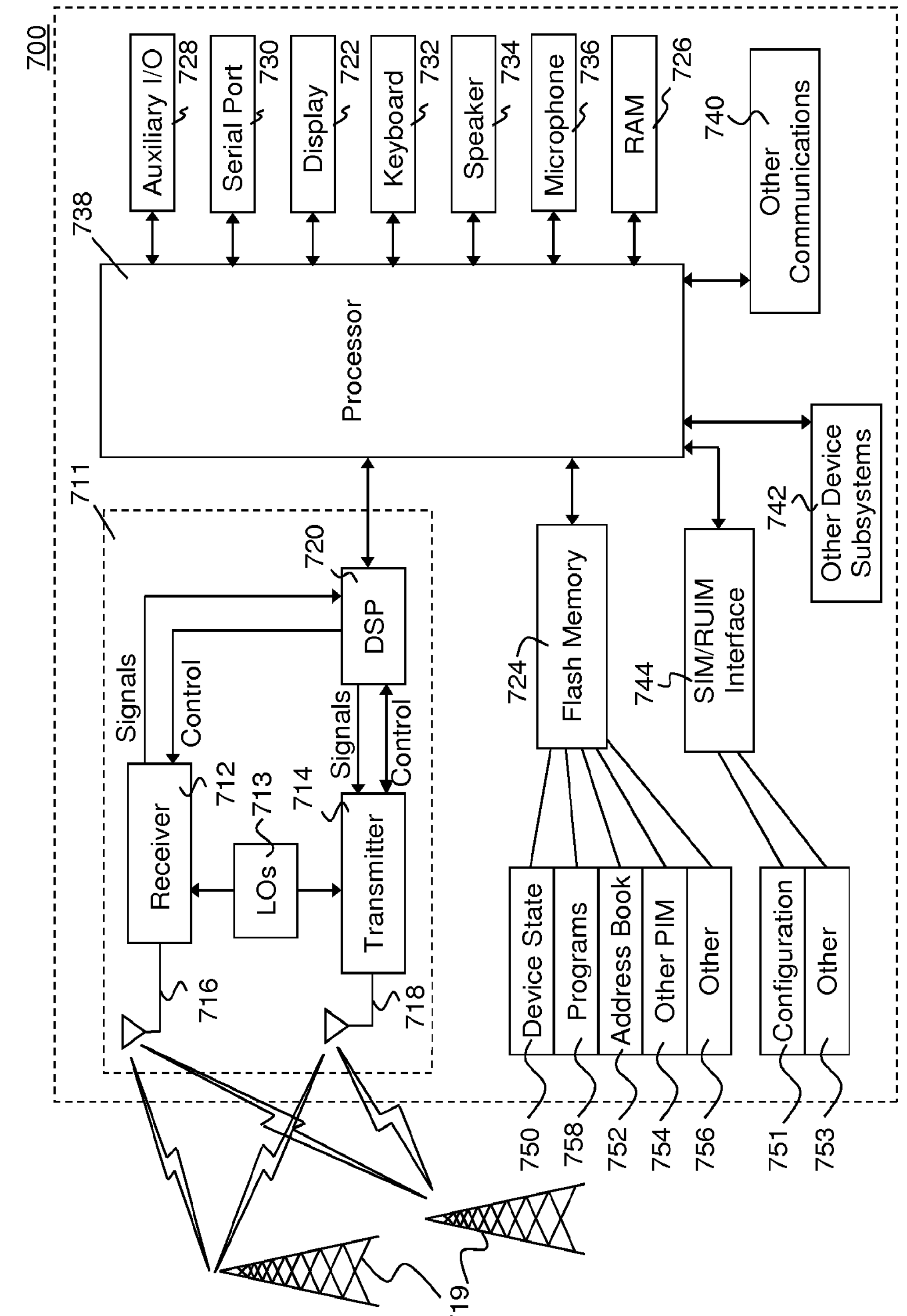
700
738
Auxiliary I/O
728
Serial Port
730
Display
722
Keyboard
732
Speaker
734
Microphone
736
RAM
726
Other Communications
740
Processor
711
DSP
720
Signals
Control
Receiver
712
LOs
713
Transmitter
714
716
718
Flash Memory
724
SIM/RUIM Interface
744
Other Device Subsystems
742
Device State
Programs
Address Book
Other PIM
Other
Configuration
Other
750
758
752
754
756
751
753
719

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/044953

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H04B 1/04 (2011.01)
USPC - 455/125
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - H04B 1/04, 1/40, 1/44, 1/46 (2011.01)
USPC - 455/77, 87, 120, 125

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,767,807 A (PRITCHETT) 16 June 1998 (16.06.1998) entire document	1-17
Y	US 2006/0246953 A1 (YAMAMOTO et al) 02 November 2006 (02.11.2006) entire document	1-17
A	US 2003/0156061 A1 (OHIRA) 21 August 2003 (21.08.2003) entire document	1-17
A	US 2006/0252391 A1 (POILASNE) 09 November 2006 (09.11.2006) entire document	1-17

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 November 2011	09 DEC 2011

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