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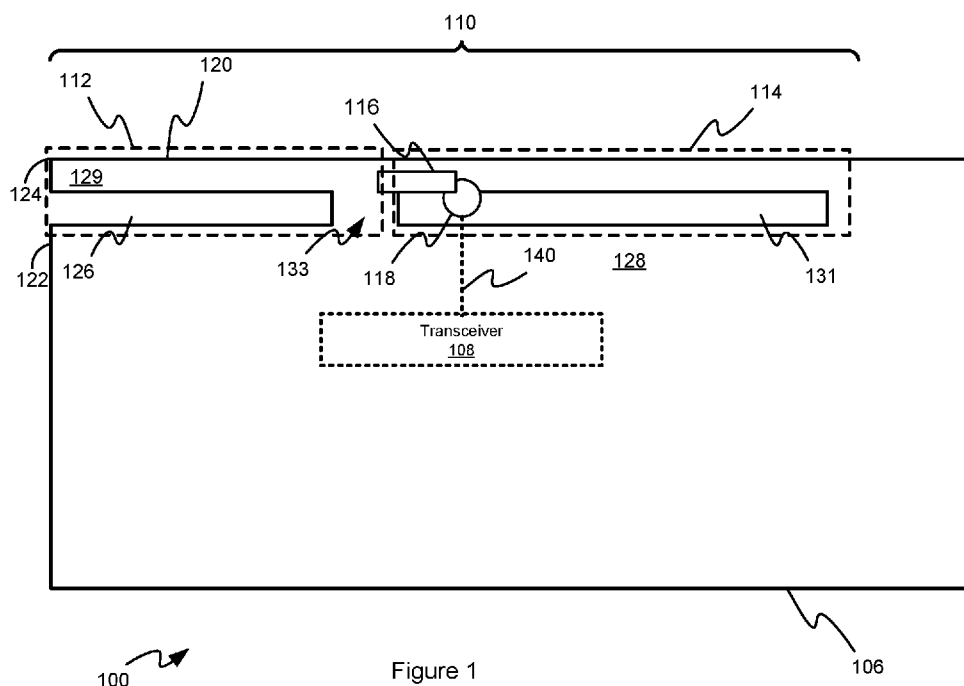


Figure 1

(57) Abstract: An example device comprises: a chassis; a transceiver; a multiband antenna comprising: a first antenna structure comprising: an open slot antenna structure, the first antenna structure to operate in a first frequency range; and, a second antenna structure comprising a closed slot antenna structure or a planar inverted-F antenna (PIFA) structure, the second antenna structure to operate in a second frequency range higher than the first frequency range, the first antenna structure and the second antenna structure arranged linearly along an edge of the chassis; and, a frequency filter joining the first antenna structure and the second antenna structure, the frequency filter to filter frequencies associated with first antenna structure and the second antenna structure, respectively; and, an antenna feed to connect the transceiver to the first antenna structure and the second antenna structure.

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MULTI-BAND ANTENNAS

BACKGROUND

[0001] Laptop computers, and the like, often include antennas.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Reference will now be made, by way of example only, to the accompanying drawings in which:

[0003] Figure 1 is a schematic view of an example device including a multiband antenna comprising a first antenna structure and a second antenna structure arranged linearly along an edge of a chassis.

[0004] Figure 2 is a schematic view of an example device including a multiband antenna comprising a first antenna structure and a second antenna structure arranged linearly along a top edge of a bezel between a display screen and the top edge.

[0005] Figure 3 depicts an example bezel of the device of Figure 2.

[0006] Figure 4 is a schematic view of an example device including a multiband antenna comprising a first antenna structure and a second antenna structure arranged linearly along a top edge of a bezel between a display screen and the top edge.

[0007] Figure 5 is a side view of the example device of Figure 4 with a keyboard in a laptop position and a tablet position, showing a relative position of a board of the antennas relative to the keyboard.

DETAILED DESCRIPTION

[0008] In consumer electronics, and the like, providing multiband antennas adjacent display screens may be challenging. For example, consumer electronics products often attempt to maximize the screen-to-body ratio (STBR), such that a size of a display screen relative to a surrounding bezel is maximized. Such high STBRs may bring challenges to incorporating antennas into such bezels, for example to also provide antennas with capability for communicating over legacy WiFi frequency bands (as well as Wifi-6E frequency bands, while balancing low specific absorption rate (SAR). For example, WiFi 6 operates in a 2.4 GHz frequency band (e.g., about 2.3 GHz to about 2.5 GHz) and a 5 GHz frequency band (e.g., about 5.1 GHz to about 5.9 GHz); WiFi-6E operates in the same frequency bands as WiFi 6, as well as a in a 6 GHz frequency band (e.g., about 5.9 GHz to about 7.2 GHz).

[0009] Hence, provided herein are devices that include a multiband antenna comprising a first antenna structure and a second antenna structure arranged linearly along an edge of a chassis and/or a bezel of a device. The first antenna structure may comprise an open slot antenna structure with a length and/or dimensions and/or a structure selected for communicating in a frequency range of about 2.3 GHz to about 2.6 GHz. The second antenna structure may comprise a closed slot antenna structure or a planar inverted-F antenna (PIFA) structure with a length and/or dimensions and/or a structure selected for communicating in a frequency range of about 5 GHz to about 7.5 GHz. As the antenna structures are laid out linearly, for example end-to-end, with at least a substantive portion of radiating portions of the antenna structures being generally non-overlapping, the antenna structures may be provided with dimensions suitable for incorporation between a display screen and an edge (e.g., a top edge) of a bezel (and/or a chassis) of a device. In a particular example the antennas may have a width which allows for a relatively high STBR, for example 90%. For example, as will be described below, when antenna structures described herein include a combination of an open slot antenna structure and a closed slot antenna structure, the antenna structures are non-overlapping; however, when antenna structures described herein

include a combination of an open slot antenna structure and a planar inverted-F antenna (PIFA) structure, the antenna structures are non-overlapping other than at a gap in a bezel (and/or a chassis) of a device that forms an opening of the open slot antenna (e.g. the PIFA structure may be located at the gap in a bezel (and/or a chassis) of a device that forms an opening of the open slot antenna). Furthermore, the example antenna structures may also be used to achieve a relatively low SAR.

[0010] An aspect of the present specification provides a device comprising: a chassis; a transceiver; a multiband antenna comprising: a first antenna structure comprising an open slot antenna structure, the first antenna structure to operate in a first frequency range; and, a second antenna structure comprising a closed slot antenna structure, the second antenna structure to operate in a second frequency range higher than the first frequency range, the first antenna structure and the second antenna structure arranged linearly along an edge of the chassis; and, a frequency filter joining the first antenna structure and the second antenna structure, the frequency filter to filter frequencies associated with first antenna structure and the second antenna structure, respectively; and, an antenna feed to connect the transceiver to the first antenna structure and the second antenna structure.

[0011] Another aspect of the specification provides a device, comprising: a display screen; a bezel having: a top edge and a side edge joined to the top edge around the display screen, the bezel comprising a conducting material; a transceiver; a multiband antenna comprising: a first antenna structure comprising an open slot antenna structure, the first antenna structure to operate in a first frequency range; a second antenna structure comprising a PIFA structure, the second antenna structure to operate in a second frequency range higher than the first frequency range, the first antenna structure and the second antenna structure arranged linearly, end-to-end, along the top edge of the bezel; and, a frequency filter joining the first antenna structure and the second antenna structure, the frequency filter to filter frequencies associated with first antenna structure and the second antenna structure, respectively; and, an antenna feed to connect the transceiver to the first antenna structure and the second antenna

structure.

[0012] Another aspect of the specification provides a device comprising: a display screen; a bezel including; a display-screen side adjacent the display screen; a top edge; and a side edge joined to the top edge at a corner around the display screen, the bezel comprising a conducting material; a multiband antenna comprising: a first antenna structure comprising an open slot antenna structure, the first antenna structure to operate in a first frequency range; a second antenna structure comprising a planar inverted-F antenna (PIFA) structure, the second antenna structure to operate in a second frequency range higher than the first frequency range, the first antenna structure and the second antenna structure arranged linearly along the top edge of the bezel at the display-screen side starting from the corner; and, a frequency filter joining the open slot antenna structure and the PIFA structure, the frequency filter to filter frequencies associated with the open slot antenna structure and the PIFA structure, respectively; and, an antenna feed connected to the first antenna structure and the second antenna structure.

[0013] Attention is next directed to FIG. 1 which depicts a device 100 that includes a multiband antenna incorporated at an edge of a chassis and/or bezel thereof. The device 100 may include, but is not limited to, a laptop device, a tablet device, a portable device, combinations thereof (e.g., a laptop device with a foldable keyboard to transform the laptop device into a tablet device), and the like. While details of non-antenna related components of the device 100 are not depicted (e.g., a display screen, input devices such as a keyboard, etc.), it is understood that the device 100 may include any suitable combination of components to provide the device 100 with any suitable functionality.

[0014] As depicted, the device 100 includes a: chassis 106; a transceiver 108; a multiband antenna 110 comprising: a first antenna structure 112; a second antenna structure 114; and, a frequency filter 116 joining the first antenna structure 112 and the second antenna structure 114, the frequency filter 116 to filter frequencies associated with first antenna structure 112 and the second antenna structure 114, respectively.

[0015] The device 100 further comprises an antenna feed 118 to connect the transceiver 108 to the first antenna structure 112 and the second antenna structure 114. The antenna structures 112, 114 are indicated by dashed lines to generally show components of the antenna structures 112, 114, as described in more detail below; however the frequency filter 116 and the antenna feed 118, within the dashed line indicating the second antenna structure 114) may not be components of the antenna structures 112, 114, though the frequency filter 116 may be a component of the multiband antenna 110.

[0016] Furthermore, the transceiver 108 is depicted in dashed lines (e.g., of a different pattern than the dashed lines showing the antenna structures 112, 114) to indicate that the transceiver may be located interior to the device 100. The transceiver 108 may comprise any suitable transceiver, or combination of transceivers, compatible with frequencies of the antenna structures 112, 114, described in more detail below. In a particular example, the transceiver 108 may comprise a WiFi transceiver compatible with a legacy WiFi frequency range of between about 2.3 GHz and about 2.6 GHz, and a WiFi-6E frequency range of between about 5 GHz and about 7.5 GHz, such that the transceiver 108 is to transmit and receive (e.g., via the antennas structures 112, 114) radio-frequency (RF) signals in these frequency ranges. Such frequency ranges may interchangeably be referred to as frequency bands.

[0017] Furthermore, as will be described in more detail below, non-radiative components of the multiband antenna 110, and in particular non-radiative components of the first antenna structure 112 and the second antenna structure 114, are not depicted such that details of radiative components of the antenna structures 112, 114, such as slots and the like, are visible in FIG. 1. As described below, electrically conducting components of the multiband antenna 110, and in particular electrically conducting components of the first antenna structure 112 and the second antenna structure 114 may be mounted on a board and/or boards, which are not depicted to show structure of the radiative components of the antenna structures 112, 114.

[0018] Furthermore, as depicted, the chassis 106 comprises various edges

including, but not limited to, a top edge 120 and a side edge 122, about perpendicular to the top edge 120. The edges 120, 122 generally form a corner 124 of the device 100.

[0019] While the term “top edge” is a relative term, as used herein, the term is understood to refer to an edge of a device and/or chassis and/or a bezel (e.g., of a display screen) which is in top-most position (e.g., relative to the ground and/or the earth) when a device is used by a user in certain positions. For example, a laptop computer may be used in a position with a display screen in an upright position, and top edge of the laptop computer may be understood to be an edge of a chassis and/or bezel that is above the display screen in such an upright position. However, as devices may often be used in landscape or portrait modes (e.g., as with tablet devices), it is understood that a “top edge” of a device and/or chassis and/or bezel may be an edge that is most upright in one use position of the device, but not another use position. Hence, it is understood that a top edge may be rotated 90° and/or 180° when the device is similarly rotated for use in other positions. Hence the term “top edge” may include any suitable edge of a device and/or chassis and/or bezel.

[0020] Details of the antenna structures 112, 114 are next described.

[0021] In particular, as depicted, the first antenna structure 112 comprises an open slot antenna structure including an open slot 126 extending from the side edge 122 of the chassis 106, the open slot 126 being adjacent and about parallel to the top edge 120 of the chassis 106. It is understood that the chassis 106 is formed from a conducting material including, but not limited to, copper, aluminum, steel, conducting plastics, and the like, and or any suitable conducting material. In particular, the conducting material of the chassis 106 may further be suitably rigid to provide the device 100 with structural stability.

[0022] In particular, the open slot 126 is open at the side edge 122 (e.g., the open slot 126 is surrounded on three sides by conducting material of the chassis 106, and open at a fourth side). Put another way, the open slot 126 comprises an opening in the side edge 122 that extends into the chassis 106 about parallel to the top edge 120, for example at the corner 124 of the chassis

106. The open slot 126 may hence comprise a straight and/or linearly shaped open slot.

[0023] The open slot 126 is furthermore understood to be “through” the chassis 106 from a depicted visible “front” face 128 of the chassis 106 to a “back” and/or “rear” face of the chassis 106 (not visible in FIG. 1, but understood to be opposite the face 128). In other words, the open slot 126 comprises a gap in the chassis 106, and material may be removed from the chassis 106 to form the open slot 126. Other slots described herein may be formed in a similar manner (whether open slots or closed slots).

[0024] In general, the open slot 126 comprises a radiating portion of the first antenna structure 112 and is understood to transmit and receive RF signals at frequencies defined by a length and/or dimensions and/or a structure of the open slot 126. However, a portion 129 (e.g., an arm) of the chassis 106 which forms the open slot 126 and is located between the open slot 126 and the top edge 120 (e.g., the portion 129 being linear in shape) may also comprises a radiating portion (e.g., a radiating arm) of the first antenna structure 112. In particular, the first antenna structure 112 is to operate in a first frequency range, and in particular examples, the first frequency range may be between about 2.3 GHz and about 2.6 GHz (e.g., a frequency range of legacy WiFi and/or WiFi 6, for example relative to WiFi-6E), with a length and/or dimensions and/or structure of the open slot antenna structure, including, but not limited to, the open slot 126 (e.g., and the portion 129), adapted therefor, described in more detail below. Put another way, a length and/or dimensions and/or structure of the open slot antenna structure, including, but not limited to, the open slot 126 (e.g., and the portion 129) is selected to satisfy boundary conditions of a 2.4 GHz band (e.g., a frequency range of about 2.3 GHz to about 2.6 GHz).

[0025] While not depicted (e.g., to better show the open slot 126 and the portion 129), the first antenna structure 112 is understood to include an electrical coupling portion (interchangeably referred to hereafter as the coupling portion) that extends from the frequency filter 116 along the open slot 126 and the portion 129; such a coupling portion comprises any suitable conducting material

(e.g., of any suitable shape and/or structure and/or dimensions) that: feeds RF signals from the transceiver 108, via the antenna feed 118 and the frequency filter 116, to the open slot 126 (e.g., to radiate the RF signals via the open slot 126 and/or the portion 129); and/or receives RF signals from the open slot 126 (e.g., as received via the open slot 126 and/or the portion 129) and relays the RF signals to the transceiver 108 via the frequency filter 116 and the antenna feed 118. Hereafter, it is understood that any electrical coupling portion described hereafter has similar functionality (e.g., conducts RF signals to and from radiating portions of antennas).

[0026] As depicted, the second antenna structure 114 comprises a closed slot antenna structure including a closed slot 131 about parallel to the top edge 120 of the bezel, the closed slot antenna structure separated from the open slot 126 of the first antenna structure 112 by a portion 133 of the chassis 106. The closed slot 131 may hence comprise a straight and/or linearly shaped closed slot.

[0027] The closed slot 131 generally comprises a slot that does not extend from an edge of the chassis 106 (e.g., the closed slot 131 is surrounded by conducting material of the chassis 106) but rather is “through” the chassis 106 from the depicted visible “front” face of the chassis 106 to a “back” face of the chassis 106. In other words, the closed slot 131 comprises a gap in the chassis 106. Conducting material may be removed from the chassis 106 to form the closed slot 131.

[0028] In general, the closed slot 131 comprises a radiating portion of the second antenna structure 114, and is understood to transmit and receive RF signals at frequencies defined by a length and/or dimensions and/or a structure of the closed slot 131. In particular, the second antenna structure 114 is to operate in a second frequency range higher than the first frequency range of the first antenna structure 112. In particular examples, the second frequency range may be between about 5 GHz and about 7.5 GHz (e.g., a frequency range of WiFi-6E), with a structure of the closed slot antenna structure, including, but not limited to, the closed slot 131, adapted therefor, described in more detail below.

Put another way, a length and/or dimensions and/or structure of the closed slot antenna structure, including, but not limited to, the closed slot 131 is selected to satisfy boundary conditions of a 5 GHz band and a 6 GHz band (e.g., a frequency range of about 5 GHz to about 7.5 GHz).

[0029] While not depicted, the second antenna structure 114 includes an electrical coupling portion (interchangeably referred to hereafter as a coupling portion) that extends from the antenna feed 118 along the closed slot 131. Such a coupling portion of the second antenna structure 114 is similar to a coupling portion the first antenna structure 112, but adapted for the functionality of the second antenna structure 114.

[0030] It is understood that, while not depicted, electrical conducting portions of the antenna structures 112, 114 may be mounted on a board and/or boards, such as a printed circuit board (PCB) and/or PCBs (interchangeably referred to hereafter as a board, which may include more than one board and/or more than one PCB board), and attached to the face 128 (and/or a rear face of the chassis 106, opposite the face 128). The frequency filter 116, described in more detail below, may also be mounted to the board. The antenna feed 118 may be through the face 128 of the chassis 106 (e.g., from an interior of the device 100) and electrically coupled to suitable conducting components of the antenna structures 112, 114 (e.g., as depicted, the antenna feed 118 is electrically coupled to the frequency filter 116, as well as a respective coupling portion of the second antenna structure 114, for example at a board to which they are mounted).

[0031] As depicted, the first antenna structure 112 and the second antenna structure 114, of the multiband antenna 110, are arranged linearly along an edge of the chassis 106 and in particular the top edge 120 of the chassis 106. As used herein, the term “linearly” may be understood to include radiating portions of the antenna structures 112, 114 being arranged along, and/or about, a line (e.g., a line that extends along, and/or about parallel to, respective long dimensions of the antenna structures 112, 114). For example, the slots 126, 131 are arranged linearly, end-to-end, about parallel to the top edge 120, and

separated by the portion 133. In particular, the antenna structures 112, 114 are non-overlapping and/or components of the antenna structures 112, 114 (and in particular radiating components of the antenna structures 112, 114) are not physically “on” each other and/or stacked onto each other but extend linearly in opposing directions from the antenna feed 118 and/or the frequency filter 116. Such a linear arrangement allows the antenna structures 112, 114 to be located in a narrow region extending perpendicularly from the top edge 120 into the chassis 106 while also not increasing a thickness of the chassis 106 (e.g., between the front face 128 and an opposing back face), other than to include a board and/or boards (e.g., on which the conducting portions of the antenna structures 112, 114 may be located). Such board and/or boards may be located at the front face 128 and/or at an opposing rear face of the chassis 106.

[0032] In general, the antenna feed 118 is to connect the transceiver 108 to the first antenna structure 112 and the second antenna structure 114, for example via an electrical connection 140 (also depicted in broken lines to indicate that the electrical connection 140 is interior to the chassis 106). As has already been described, the antenna feed 118 may be from an interior of the device 100, through the face 128 of the chassis 106, and electrically coupled to suitable conducting components of the antenna structures 112, 114, such as the frequency filter 116, which is electrically coupled to the first antenna structure 112 via a corresponding coupling portion, and a coupling portion of the second antenna structure 114.

[0033] As depicted, the frequency filter 116 is joining the first antenna structure 112 and the second antenna structure 114; in particular, the frequency filter 116 is electrically coupled to and/or electrically joining the respective coupling portions of the antenna structures 112, 114. The frequency filter 116 is to filter frequencies associated with first antenna structure 112 and the second antenna structure 114. For example, the frequency filter 116 may comprise an inductor-capacitor (LC) network mounted on the board between the respective coupling portions of the antenna structures 112, 114, and the LC network may comprise any suitable combination of electrical component (e.g., including, but not limited to, inductors and capacitors) which allow first frequencies of the first antenna

structure 112 to pass to and from the first antenna structure 112, and the antenna feed 118, but prevent second frequencies of the second antenna structure 114 to pass to and from the first antenna structure 112, and vice versa.

[0034] In general, as a length and/or dimensions of the open slot 126 is generally selected to satisfy boundary conditions (e.g., and/or to satisfy a resonant condition) of a given frequency band (e.g., a 2.4 GHz band), RF current generally excites radiation via the open slot 126 (and/or the portion 129) in the given frequency band. As such, while RF current at the given frequency band may flow through the closed slot 131, such RF current at the given frequency band won't generally excite the radiation at the close slot 131, whose length and/or dimensions are selected to satisfy boundary conditions of a different and/or higher given frequency band (e.g., a 5 GHz band and a 6 GHz band). While RF currents at the different (e.g., higher) given frequency band of the closed slot 131 may excite both the open slot 126 and the closed slot 131, as radiation characteristics of open slot antennas at non-fundamental frequencies are usually poor, filtering characteristics of the frequency filter 116, in the position as depicted, may provide a high resistance and/or reactance to the different (e.g., higher) given frequency band of the closed slot 131 to stop and/or reduce the RF current of the different (e.g., higher) given frequency band of the closed slot 131 flowing to the open slot 126, such that a substantial portion of the radiation at this band is provided to the closed slot 131.

[0035] While the antenna feed 118 is depicted as being located between the first antenna structure 112 and the second antenna structure 114, the antenna feed 118 may be located in any suitable location including, but not limited to, at the first antenna structure 112 (e.g., electrically connected to a coupling portion of the first antenna structure 112 at any suitable location, and electrically on either side of the frequency filter 116), at the second antenna structure 114 (e.g., electrically connected to a coupling portion of the second antenna structure 114 at any suitable location), with the frequency filter 116 adapted accordingly.

[0036] Furthermore, while the antenna feed 118 is depicted as being of a size and position such that the antenna feed 118 directly electrically connects to the

frequency filter 116, the antenna feed 118 may be of a different size and/or position and connected to the frequency filter 116 via any suitable electrical connections (e.g., an electrical trace on a board to which the antenna feed 118 connects and at which the frequency filter 116 is located). It is hence further understood that respective coupling portions of the antenna structures 112, 114 may be similarly adapted and electrically connected to other electrical components of the device 100 via any suitable combination of electrical connections.

[0037] As mentioned above, the dimensions and/or structure of the antenna structures 112, 114 are adapted for the respective frequency ranges and/or bands. For example, for frequencies in an about 2.3 GHz to about 2.6 GHz frequency range, the open slot 126, a length of the open slot 126 may be selected to satisfy boundary condition of resonance at about a 2.3 GHz to about 2.6 GHz band and/or range (e.g., and/or at about a 2.4 GHz band,). Similarly, for frequencies in an about 5 GHz to about 7.5 GHz frequency range, a length of the closed slot 131 may be selected to satisfy boundary condition of resonance at about a 5.0 to 7.5 GHz band and/or range (e.g., and/or at about a 5GHz band and a 6 GHz band), .

[0038] Furthermore, a distance between respective top edges of the slots 126, 131 (e.g., edges of the slots 126, 131 closest to the top edge 120) and the top edge 120 of the chassis 106 may allow for an STBR of about 90%.

[0039] For example, the antenna structures 112, 114, may be located in a region that is of the chassis 106 along the top edge 120 that is relatively narrow, such that when the chassis 106 includes a bezel around a display screen (not depicted), the bezel may have a width along the top edge 120 that allows for an STBR of about 90%.

[0040] It is hence further understood that scale of FIG. 1 is not “to size” but rather a size of the antenna structures 112, 114 and associated components, relative to the chassis 106 and the remainder of the device 100, is exaggerated to show structure thereof, and that the size of the antenna structures 112, 114 and associated components, relative to the chassis 106 and the remainder of

the device 100, may be relatively small.

[0041] In particular, the antenna structures 112, 114 are located such that components of a display screen do not interfere with transmitting and receiving of RF signals by the antenna structures 112, 114. For example, display screens include metal traces, and the like, and if a display screen extended into a region of the antenna structures 112, 114, the display screen might electrically interfere with the antenna structures 112, 114. With the antenna structures 112, 114, fitting into a relatively narrow dimension (e.g., extending perpendicular to the top edge 120), the antenna structures 112, 114 may extend along a respective top edge of a display screen, between the display screen and the top edge 120, providing an STBR of about 90%. For example, a display screen for a tablet and/or a laptop computer may be on the order of about 150 mm to about 450 mm (e.g., about 6 to about 17 inches) on a diagonal thereof, and hence a bezel at top edge thereof may be on the order of about 6 mm to about 7 mm to incorporate the antenna structures 112, 114, achieving a relatively high STBR of about 90%.

[0042] Furthermore, other features are within the scope of the present specification. For example, the slots 126, 131 may be filled and/or partially filled, with a non-conducting material, such as any suitable non-conducting plastic (e.g., a non-conducting suitable hard plastic, and the like) which may be provided as inserts to the slots 126, 131. Such inserts may be glued, and the like (e.g., using any suitable adhesive) into the slots 126, 131 and/or held in place via any suitable combination of mechanical fasteners and/or such inserts may include grooves, and the like, such that the inserts “snap” and/or slide into the slots 126, 131. Such non-conducting material in the slots 126, 131 may assist with providing structural stability to the top edge 120 of the chassis 106 (e.g., as removal of the material to form the slots 126, 131 may affect structural stability of the chassis 106).

[0043] Furthermore, the antenna structures 112, 114 (e.g., including the slots 126, 131, and respective coupling portions of the antenna structures 112, 114), the frequency filter 116, as well any boards to which the respective coupling

portions of the antenna structures 112, 114 and the frequency filter 116 are mounted, may be covered and/or partially covered, by an external non-conducting housing to hide and/or protect such components.

[0044] In yet further examples, duplicates of the antenna structures 112, 114 may be located at more than one corner and/or at more than one edge of the device 100, to provide redundancy. For example, duplicates of the antenna structures 112, 114 may be located at opposing corners of the top edge 120, with an additional antenna feed and frequency filter provided accordingly, along with an appropriate electrical connection to the transceiver 108.

[0045] In yet further examples, the first antenna structure 112 and the second antenna structure 114 may be adapted for other configurations, as described hereafter. For example, the second antenna structure 114 may be replaced with a planar inverted-F antenna (PIFA) structure, with the open slot 126 of the first antenna structure 112, and the chassis 106 adapted accordingly.

[0046] For example, attention is next directed to FIG. 2 which depicts a device 200, similar to the device 100, with like components having like numbers, but in a “200” series rather than “100” series. However, in contrast to the device 100, the device 200 comprises a display screen 202, in addition to other differences described hereafter. As depicted, the device 200 may comprise a tablet device, a mobile device, and the like, and/or a portion of a laptop device (e.g., depicted without a keyboard). However, the device 200 may comprise any suitable device.

[0047] As depicted, the device 200 comprises: the display screen 202 (e.g., an light emitting diode (LED) display, an organic LED display, a plasma display and the like with, for example, a touch screen integrated with the display screen 202), a bezel 206 (e.g., similar to the chassis 106 but surrounding, and/or partially surrounding the display screen 202); a transceiver 208; a multiband antenna 210 comprising: a first antenna structure 212; a second antenna structure 214; and, a frequency filter 216 joining the first antenna structure 212 and the second antenna structure 214, the frequency filter 216 to filter frequencies associated with first antenna structure 212 and the second antenna

structure 214, respectively. The device 200 further comprises an antenna feed 218 to connect the transceiver 208 to the first antenna structure 212 and the second antenna structure 214. As with the FIG. 1, in FIG. 2 a size of the antenna structures 212, 214 is exaggerated relative to the display screen 202 and the bezel 206 to show structure of the antenna structures 212, 214.

[0048] Similar to the chassis 106, the bezel 206 comprises a top edge 220 and a side edge 222 joined to the top edge 220 around the display screen 202, and forming a corner 224. Furthermore, similar to the chassis 106, the bezel 206 is understood to be formed from a conducting material.

[0049] Similar to the first antenna structure 112 of the device 100, the first antenna structure 212 comprises an open slot antenna structure, the first antenna structure 212 to operate in a first frequency range (similar to the first frequency range of the first antenna structure 112). However, in contrast to the first antenna structure 112, the open slot antenna structure of the first antenna structure 212 comprises an L-shaped open slot 226 in the bezel 206 (e.g., formed by a gap in a face and/or a display-screen side 228 of the bezel 206, similar to the face 128), rather than a straight open slot. With brief reference to FIG. 3, which depicts the bezel 206 without other components of the device 200, the L-shaped open slot 226 includes a long portion 226-1 (e.g., a length of which is indicated by the arrow 302 parallel thereto), that extends about parallel to the top edge 220 of the bezel 206, and a gap 226-2 (e.g., a width of which is indicated by an arrow 304 parallel thereto), perpendicular to the long portion 226-1, that opens at the top edge 220 of the bezel 206. As will be described below, dimensions of the gap 226-2 are also adapted for a PIFA structure of the second antenna structure 214. Furthermore, a portion 226-3 of the bezel 206, between the long portion 226-1 and the top edge 220, may form part of the first antenna structure 212; for example the portion 226-3 may comprise a radiating component of the first antenna structure 212 similar to the portion 129.

[0050] However, while all three of the long portion 226-1, the gap 226-2 and the portion 226-3 form radiating components of the first antenna structure 212, the substantive portion of radiating of the first antenna structure 212 occurs via the

long portion 226-1 and the portion 226-3 (e.g., while some radiating of the first antenna structure 212 may occur via the gap 226-2, such radiating is understood to be small relative to the long portion 226-1 and the portion 226-3).

[0051] Returning to FIG. 2, the first antenna structure 212 comprises an electrical coupling portion 230 (interchangeably referred to hereafter as the coupling portion 230) that extends from the frequency filter 216 along the long portion 226-1 of the L-shaped open slot 226, and is otherwise similar to a respective coupling portion of the first antenna structure 112.

[0052] In further contrast to the device 100, the second antenna structure 214 comprises a PIFA structure 231. For example, the PIFA structure 231 is located at the gap 226-2 in the bezel 206 of the open slot antenna structure and/or of the L-shaped open slot 226 of the first antenna structure 212. Again with reference to FIG. 3, the relative positions of the long portion 226-1 and the gap 226-2 of the L-shaped open slot 226 are shown. In general, the gap 226-2 is removed from the bezel 206 so as to prevent the conducting material of the bezel 206 from electrically interfering with the PIFA structure 231 as well as to provide an opening for the L-shaped open slot 226.

[0053] In particular, it is understood that the first antenna structure 212 and the second antenna structure 214 are partially formed using gaps (e.g., the L-shaped open slot 226 and/or the long portion 226-1 and the gap 226-2) in the conducting material of the bezel 206, with the L-shaped open slot 226 comprising a radiating component of the first antenna structure 212 and the gap 226-2 comprising a non-radiating component of the second antenna structure 214 (e.g., though the gap 226-2 may form a radiating component of the L-shaped open slot 226 and/or the first antenna structure 212). In some examples, gaps of the first antenna structure 212 and the second antenna structure 214 may be filled and/or partially filled, with non-conducting material such as a non-conducting plastic described above with respect to the antenna structures 112, 114.

[0054] Similar to the antenna structure 114, the second antenna structure 214 (and in particular the PIFA structure 231) is generally to operate in a second

frequency range higher than a first frequency range of the first antenna structure 212.

[0055] For example, similar to the antenna structures 112, 114, the first frequency range the first antenna structure 212 may be between about 2.3 GHz and about 2.6 GHz, with a structure of the open slot antenna structure (e.g., the L-shaped open slot 226) of the first antenna structure 212 adapted therefor (e.g., to satisfy boundary conditions of a 2.4 GHz band), and the second frequency range may be between about 5 GHz and about 7.5 GHz, with a respective structure of the PIFA structure 231 of the second antenna structure 214 adapted therefor (e.g., to satisfy boundary conditions of a 5GHz band and a 6 GHz band).

[0056] The length of the gap 226-2 (e.g., as indicated by an arrow 306 shown in FIG. 3) and the width of the gap 226-2 (e.g., as also indicated the arrow 304), is generally selected for compatibility with dimensions and/or structure of the PIFA structure 231 of the second antenna structure 214, as well as for compatibility with boundary conditions of the first antenna structure 212. For example, enough conducting material is removed from the bezel 206 to form the gap 226-2 such that the bezel 206 does not electrically interfere with the PIFA structure 231 of the second antenna structure 214 and/or such electrical interference is minimized, with the PIFA structure 231 of the second antenna structure 214 positioned accordingly relative to the gap 226-2, described in further detail below.

[0057] Dimensions of the PIFA structure 231 of the second antenna structure 214, including a long dimension, a “top” short portion 231-1 (e.g., a “top” arm of the “F” shape of the PIFA structure 231) and a middle short portion 231-2 (e.g., a middle arm of the “F” shape of the PIFA structure 231) are generally selected to satisfy a boundary condition of resonance at about a 5.0 to 7.5 GHz range (e.g., and/or at about a 5 GHz band and a 6 GHz band). Furthermore, the middle short portion 231-2 electrically connects to an electrical coupling portion 236, that in turn electrically connects the PIFA structure 231 of the second antenna structure 214 to the antenna feed 218.

[0058] Hence, similar to the antenna structures 112, 114, the first antenna structure 212 and the second antenna structure 214 are arranged linearly, end-to-end, along the top edge 220 of the bezel 206. For example, the long portion 226-1 of the first antenna structure 212, and the long portion of the PIFA structure 231 of the first antenna structure 212 are about parallel to each other, and arranged about a line that is about parallel to each other. Furthermore, as the long portion 226-1 and/or the portion 226-3 of the bezel 206 form the substantially radiating components of the first antenna structure 212, a substantive portion of radiating portions and/or radiative components of the antenna structures 212, 214 generally do not overlap.

[0059] For example, the long portion 226-1 of the L-shaped open slot 226, as well as the portion 226-3 of the bezel 206, of the first antenna structure 212, is adjacent and/or close to, but does not overlap with, a closest end of the PIFA structure 231 of the second antenna structure 214, however the PIFA structure 231 of the second antenna structure 214 is located at the gap 226-2. Hence, put another way, the antenna structures 212, 214 are generally non-overlapping other than at the gap 226-2. However, the antenna structures 212, 214 may be any suitable distance apart, arranged linearly, end-to-end, along the top edge of the bezel 206.

[0060] Hence, similar to the antenna structures 112, 114, the antenna structures 212, 214 may be located in a relatively narrow region adjacent the top edge 220 (e.g., a region perpendicular and parallel to the top edge 220 of the bezel 206), and hence the first antenna structure 212 and the second antenna structure 214 may be located between a top 242 of the display screen 202 and the top edge 220 of the bezel 206, such that the distance between the top 242 of the display screen 202 and the top edge 220 of the bezel 206 that includes the antenna structures 212, 214 may allow for an STBR of about 90% .

[0061] In particular, the example device 200 of FIG. 2 takes advantage of a larger bandwidth of L-shaped open slot antenna structures and better radiation characteristics (e.g., as compared to as compared conventional open slot antennas and/or conventional PIFAs); as well, the example device 200 of FIG. 2

takes advantage of the bandwidth of PIFA structures, also with lower SAR (e.g., again, as compared to as compared conventional open slot antennas and/or closed slot antennas), which allows for higher operating power and hence larger operation range (e.g., to communicate with an WiFi AP (access point) router, and the like, the higher operating power and hence larger operation range relative to conventional open slot antennas and/or closed slot antennas which may have higher relative SAR). Put another way, the multiband antenna 210 may have less SAR at both a 5-GHz band and a 6-GHz band, as compared to conventional open slot antennas and/or conventional PIFAs, so the RF transceiver 208 may transmit more power at these two bands, as compared to the transceivers for conventional open slot antennas and/or conventional PIFAs, and hence extends communication coverage between the device 200 and WiFi access point, relative to conventional open slot antennas and/or conventional PIFAs,. Similarly, the multiband antenna 110 may have better radiation characteristics at least at the 2.4-GHz band, with a smaller antenna dimension for a higher STBR, relative to conventional open slot antennas and/or conventional PIFAs.

[0062] For completeness, also depicted in FIG. 2 is an electrical connection 240 that connects the transceiver 208 to the antenna feed 218, similar to the connection 140.

[0063] As has been described previously, certain electrical components of the antenna structures 212, 214, as well as the frequency filter 216, may be located on a board and/or boards which may be located at the display-screen side 228 of the bezel 206, and/or at an opposing rear side of the bezel 206. For example, the PIFA structure 231 may be located at a board, and the board may be attached to the display-screen side 228 of the bezel 206 (e.g., using a suitable adhesive, mechanical connectors, and the like) to suitably locate the PIFA structure 231 relative to the gap 226-2 and the L-shaped open slot 226, as described above.

[0064] Additionally, while the antenna structures 212, 214 are depicted as being arranged with the first antenna structure 212 being located closest to the corner

224, and the second antenna structure 214 being located furthest from the corner 224, in other examples their positions may be reversed, with the gaps in the bezel 206 adapted accordingly.

[0065] Furthermore, devices described herein may be adapted for use with laptop computers with keyboards, that may be moveable and/or foldable between a laptop position and a tablet position. Such laptop computers may have the boards of the antenna structures as described located at a display-screen side of a bezel to allow for operation of the antenna structures in both the laptop position and the tablet position of such a keyboard.

[0066] For example, attention is next directed to FIG. 4 which depicts a device 400, similar to the device 200, with like components having like numbers, but in a “400” series rather than “200” series. However, in contrast to the device 200, the device 400 comprises a display screen 402 with a keyboard 404 foldable and/or rotatably attached to the display screen 402 and/or a bezel 406 thereof, in addition to other differences described hereafter.

[0067] As depicted, the device 400 may comprise a laptop device which may be for use in an open and/or laptop position (as depicted), and a closed position (e.g., with the keyboard 404 folded and/or rotated against the display screen 402). However, in some examples, as described in more detail below with respect to FIG. 5, the keyboard 404 may be folded and/or rotated against a back side of the display screen 402, or example into a tablet position, where the a user may interact with the display screen 402 via touch input, and the like; as such, in these examples, the display screen 402 may comprise a touch screen.

[0068] As depicted, the device 400 comprises: the display screen 402; the keyboard 404 foldable attached to the display screen 402 and/or the bezel 406; the bezel 406; a transceiver 408; a multiband antenna 410 comprising: an open slot antenna structure 412 (e.g., similar to the first antenna structure 212); a PIFA structure 414 (e.g., similar to the second antenna structure 214); and, a frequency filter 416 joining the open slot antenna structure 412 and the PIFA structure 414, the frequency filter 416 to filter frequencies associated with the open slot antenna structure 412 and the PIFA structure 414, respectively. The

device 400 further comprises an antenna feed 418 connected to the open slot antenna structure 412 and the PIFA structure 414. (e.g., the antenna feed 418 to connect the transceiver 408 to the open slot antenna structure 412 and the PIFA structure 414).

[0069] For example, the open slot antenna structure 412 is generally to operate in a first frequency range, and the PIFA structure 414 is generally to operate in a second frequency range higher than the first frequency range, similar to the antenna structures 212, 214.

[0070] Similar to the bezel 206, the bezel 406 comprises a top edge 420 and a side edge 422 joined to the top edge 420 around the display screen 402, and forming a corner 424. Furthermore, similar to the bezel 206, the bezel 406 is understood to be formed from a conducting material.

[0071] As depicted, the open slot antenna structure 412 includes an L-shaped open slot 426 that extends from, and/or starts, proximate from the corner 424, and the side edge 422 (e.g., but without being open at the side edge 422), along the top edge 420, and opens at the top edge 420. As such, the open slot antenna structure 412 is understood to be at least partially formed from a gap (e.g., the L-shaped open slot 426) in the conducting material of the bezel 406.

[0072] Furthermore, similar to the bezel 206, the bezel 406 includes a display-screen side 428 adjacent the display screen 402, and the L-shaped open slot 426 comprise a gap through the bezel 406 between the display-screen side 428 and an opposing rear side (not depicted). The open slot antenna structure 412 further includes a coupling portion 430 connecting to the frequency filter 416.

[0073] Similar to the PIFA structure 231 of the second antenna structure 214, the PIFA structure 414 is located at a gap 432 (e.g. similar to the gap 226-2) in the bezel 406 (e.g., that joins with the L-shaped open slot 426) and furthermore the PIFA structure 414 includes a coupling portion 436 connecting to the antenna feed 418. As depicted, the gap 432, and the L-shaped open slot 426, is filled with a non-conducting material 434.

[0074] Similar to the antenna structures 212, 214, the open slot antenna

structure 412 and the PIFA structure 414 are arranged linearly along the top edge 420 of the bezel 406 at the display-screen side 428, starting from the corner 424 and/or the side edge 422 (e.g., but without intersecting the side edge 422). Put another way, a substantive portion of radiating components of the open slot antenna structure 412 and the PIFA structure 414 are generally non-overlapping (e.g., other than at the gap 226-2) in a linear arrangement thereof, so as to not add depth to the display-screen side 428 of the bezel 406 (e.g., relative to if the open slot antenna structure 412 and the PIFA structure 414 were substantively overlapping such that the PIFA structure 414 overlapped with a long portion of the L-shaped open slot 426, similar to the long portion 226-1).

[0075] In particular, the PIFA structure 414 is at least partially located on a board 438 (e.g., a PCB board) over the gap 432 in the bezel 406 that intersects with the open slot antenna structure 412 (e.g., the L-shaped open slot 426). In particular, as depicted, conducting portions of the open slot antenna structure 412 and the PIFA structure 414 (including the radiating portions of the PIFA structure 414) are located on the board 438 (or boards) mounted at the display-screen side 428 of the bezel 406. Hence, for example, the PIFA structure 414 and the coupling portions 430, 436 are located on the board 438 and may comprise electrical traces on the board 438. As depicted, the frequency filter 416 is also mounted on the board 438. While the components on the board 438 are depicted as being on a side of the board 438 that is facing outwards in FIG. 4, it is understood that the PIFA structure 414 and/or the coupling portion 430 and/or the coupling portion 436 may be located at an opposite side of the board 438.

[0076] For completeness, also depicted in FIG. 4 is an electrical connection 440 that connects the transceiver 408 to the antenna feed 418.

[0077] While not depicted, the board 438, the L-shaped open slot 426 and the gap 432 may be covered by a non-conducting housing.

[0078] Hence, in general, the device 400 is similar to the device 200, but includes the keyboard 404, and the board 438 is explicitly located at the display-screen side 428 of the bezel 406.

[0079] Attention is next directed to FIG. 5, which schematically depicts a side view of the device 400 with the keyboard 404 in a laptop position and a tablet position. In particular the keyboard 404 is depicted as being foldable and/or rotatably attached to the display screen 402 and/or a bezel 406 thereof via a hinge 502 such that the keyboard 404 may be folded “behind” the display screen 402 in the tablet position (as indicated by the arrow 504).

[0080] FIG. 5 also shows a position of the board 438 relative to the keyboard 404 in both the laptop position and a tablet position. In either position, the board 438 is not adjacent to the keyboard 404 and hence the antenna portions of the board, as well as the antenna structures 412, 414, may operate without interference from the keyboard 404 and/or with reduced interference from the keyboard 404, relative to if the board 438 were mounted at a side opposite the display-screen side 428.

[0081] Further alternatives are within the scope of the present specification. For example, while the devices 100, 200, 400 have been described with respect to particular arrangements of open slot antenna structures arranged linearly with either a closed slot antenna structure (as in the device 100) or a PIFA structure (as in the devices 200, 400), any of the devices 100, 200, 400 described herein may be adapted to include any suitable arrangement of an open slot antenna structures arranged linearly with either a closed slot antenna structure or a PIFA structure. For example, the antenna structures 112, 114 of the device 100 may be replaced with the antenna structures 212, 214 of the device 200. Similarly, the antenna structures 212, 214 of the device 200 and/or the open slot antenna structure 412 and the PIFA structure 414 of the device 400, may be replaced with the antenna structures 112, 114 of the device 100. Similarly, more than one of the various combinations of linearly arranged antenna structures, as described herein, may be provided the devices 100, 200, 400. For example, the device 200 may include a second set of antenna structures 212, 214 (or the antenna structures 112, 114) along the top edge 220 (e.g., at a corner opposite the corner 224) and/or along another edge (such as the side edge 222), and the like.

[0082] It should be recognized that features and aspects of the various examples provided above may be combined into further examples that also fall within the scope of the present disclosure.

CLAIMS

1. A device comprising:
 - a chassis;
 - a transceiver;
 - a multiband antenna comprising:
 - a first antenna structure comprising an open slot antenna structure, the first antenna structure to operate in a first frequency range;
 - a second antenna structure comprising a closed slot antenna structure, the second antenna structure to operate in a second frequency range higher than the first frequency range, the first antenna structure and the second antenna structure arranged linearly along an edge of the chassis; and,
 - a frequency filter joining the first antenna structure and the second antenna structure, the frequency filter to filter frequencies associated with first antenna structure and the second antenna structure, respectively;
 - and,
 - an antenna feed to connect the transceiver to the first antenna structure and the second antenna structure.
2. The device of claim 1, wherein:
 - the open slot antenna structure, of the first antenna structure, comprises a slot that extends from an opening in a side edge of the chassis about parallel to a top edge of the chassis; and,
 - the closed slot antenna structure, of the second antenna structure, is about parallel to the top edge of the chassis, the closed slot antenna structure separated from the slot of the first antenna structure by a portion of the chassis.
3. The device of claim 1, wherein the first frequency range is between about 2.3 GHz and about 2.6 GHz, with a structure of the open slot antenna structure adapted therefor, and the second frequency range is between about 5 GHz and about 7.5 GHz, with a respective structure of the closed slot antenna structure adapted therefor.

4. The device of claim 1, wherein the frequency filter comprises an inductor-capacitor (LC) network.
5. The device of claim 1, wherein the first antenna structure and the second antenna structure are substantively non-overlapping.

6. A device, comprising:
a display screen;
a bezel having: a top edge and a side edge joined to the top edge around the display screen, the bezel comprising a conducting material;
a transceiver;
a multiband antenna comprising:
a first antenna structure comprising an open slot antenna structure, the first antenna structure to operate in a first frequency range;
a second antenna structure comprising a planar inverted-F antenna (PIFA) structure, the second antenna structure to operate in a second frequency range higher than the first frequency range, the first antenna structure and the second antenna structure arranged linearly, end-to-end, along the top edge of the bezel; and,
a frequency filter joining the first antenna structure and the second antenna structure, the frequency filter to filter frequencies associated with first antenna structure and the second antenna structure, respectively;
and,
an antenna feed to connect the transceiver to the first antenna structure and the second antenna structure.
7. The device of claim 6, wherein:
the open slot antenna structure, of the first antenna structure, comprises an L-shaped open slot in the bezel, the L-shaped open slot having a long portion, that extends about parallel to the top edge of the bezel, and a short portion, perpendicular to the long portion, that opens at the top edge of the bezel; and,
the PIFA structure, of the second antenna structure, is located at a gap in the bezel that joins to the short portion of the open slot antenna structure.
8. The device of claim 6, wherein the first frequency range is between about 2.3 GHz and about 2.6 GHz, with a structure of the open slot antenna structure adapted therefor, and the second frequency range is between about 5 GHz and about 7.5 GHz, with a respective structure of the PIFA structure adapted therefor.

9. The device of claim 6, wherein the first antenna structure and the second antenna structure are partially formed using gaps in the conducting material of the bezel, the gaps filled with non-conducting material.

10. The device of claim 6, wherein the first antenna structure and the second antenna structure are located between a top of the display screen and the top edge of the bezel.

11. A device comprising:
 - a display screen;
 - a bezel including; a display-screen side adjacent the display screen; a top edge and a side edge joined to the top edge at a corner around the display screen, the bezel comprising a conducting material;
 - a multiband antenna comprising:
 - a first antenna structure comprising an open slot antenna structure, the first antenna structure to operate in a first frequency range;
 - a second antenna structure comprising a planar inverted-F antenna (PIFA) structure, the second antenna structure to operate in a second frequency range higher than the first frequency range, the first antenna structure and the second antenna structure arranged linearly along the top edge of the bezel at the display-screen side starting from the corner; and,
 - a frequency filter joining the open slot antenna structure and the PIFA structure, the frequency filter to filter frequencies associated with the open slot antenna structure and the PIFA structure, respectively; and,
 - an antenna feed connected to the first antenna structure and the second antenna structure.
12. The device of claim 11, wherein the first antenna structure extends along the top edge, starting from adjacent the corner.
13. The device of claim 11, wherein conducting portions of the first antenna structure and the second antenna structure are located on a board mounted at the display-screen side of the bezel.
14. The device of claim 11, wherein the open slot antenna structure is formed from a gap in the conducting material of the bezel.
15. The device of claim 11, wherein the antenna feed is located at the first antenna structure, the second antenna structure or between the first antenna

structure and the second antenna structure.

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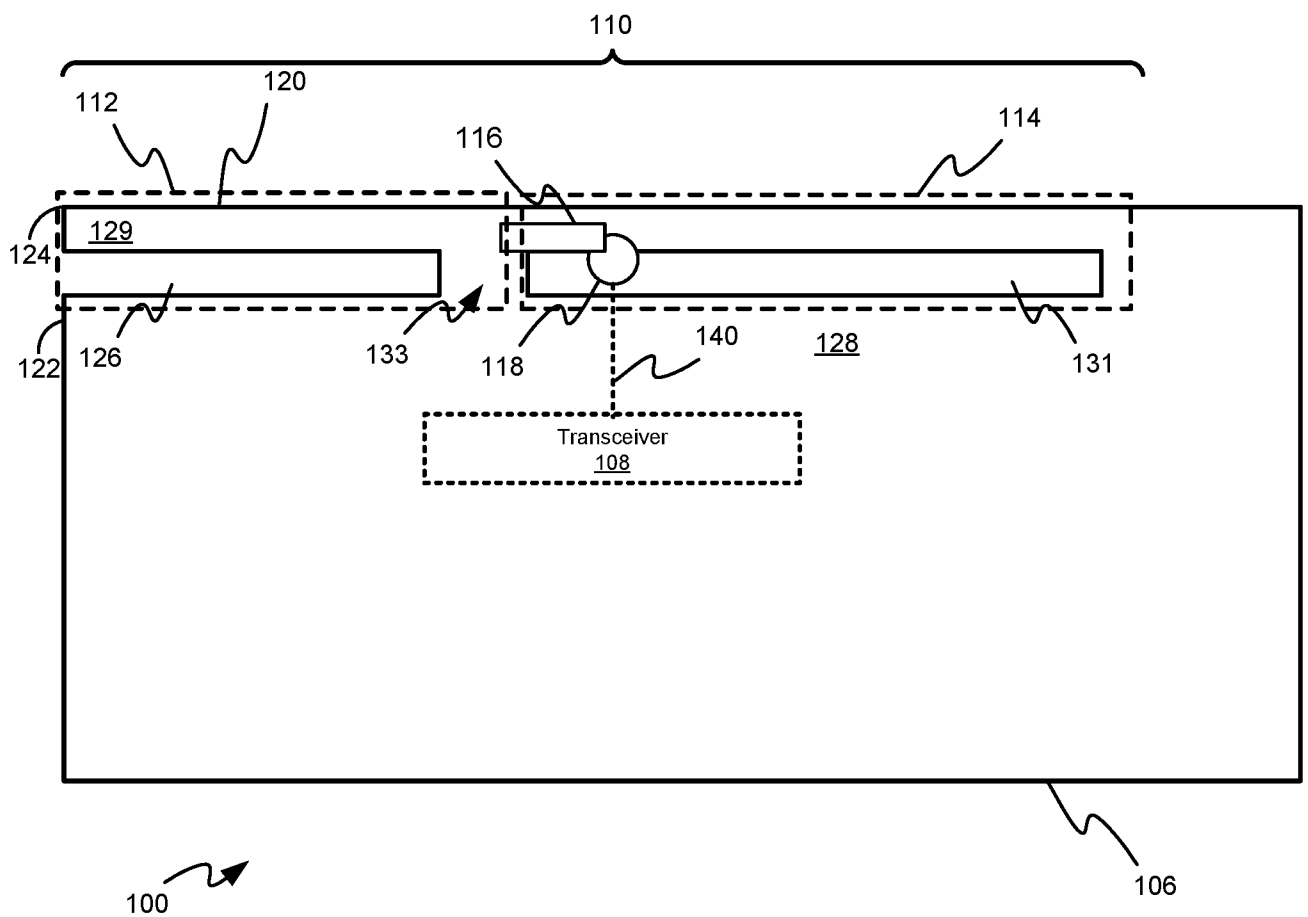


Figure 1

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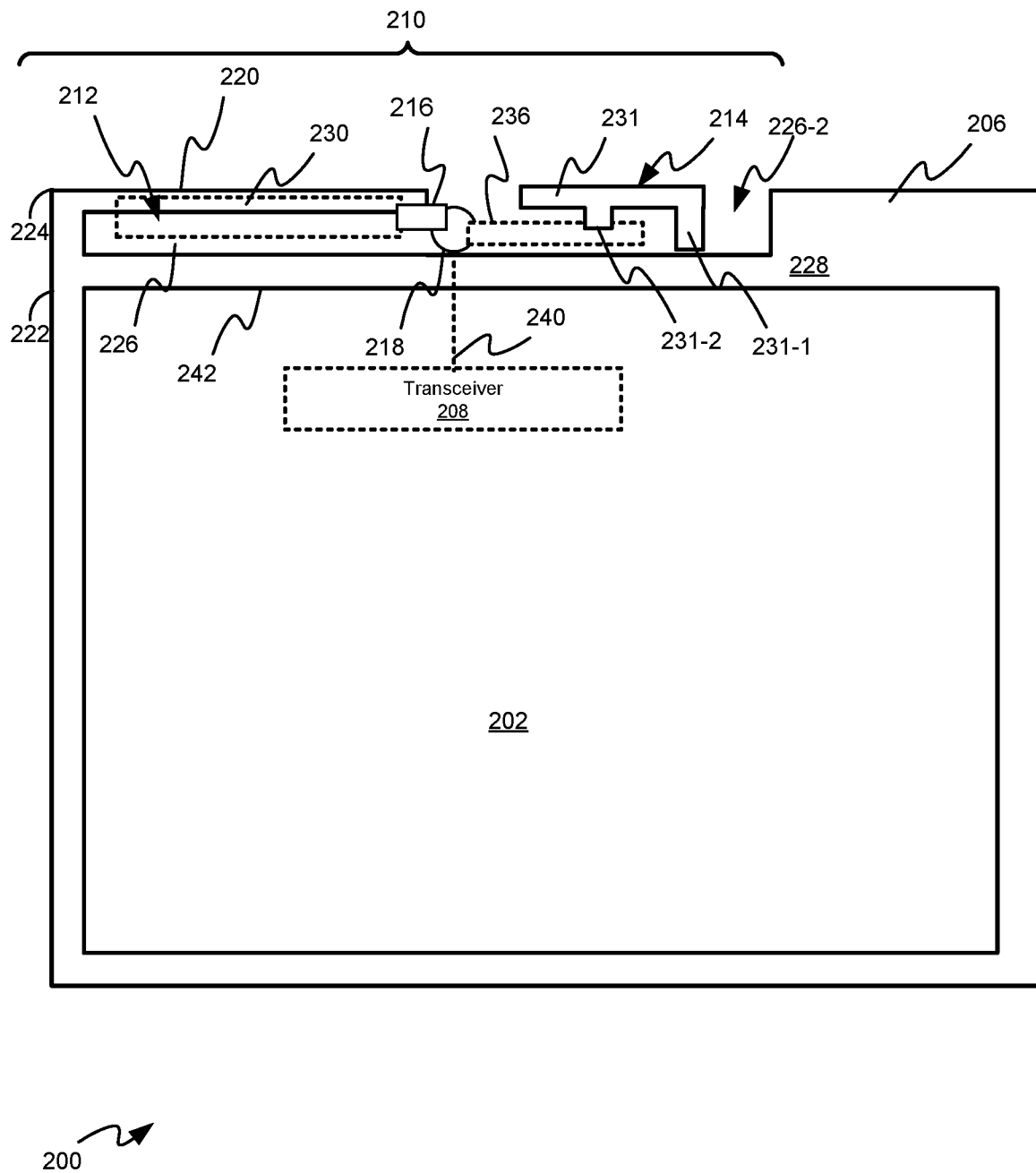


Figure 2

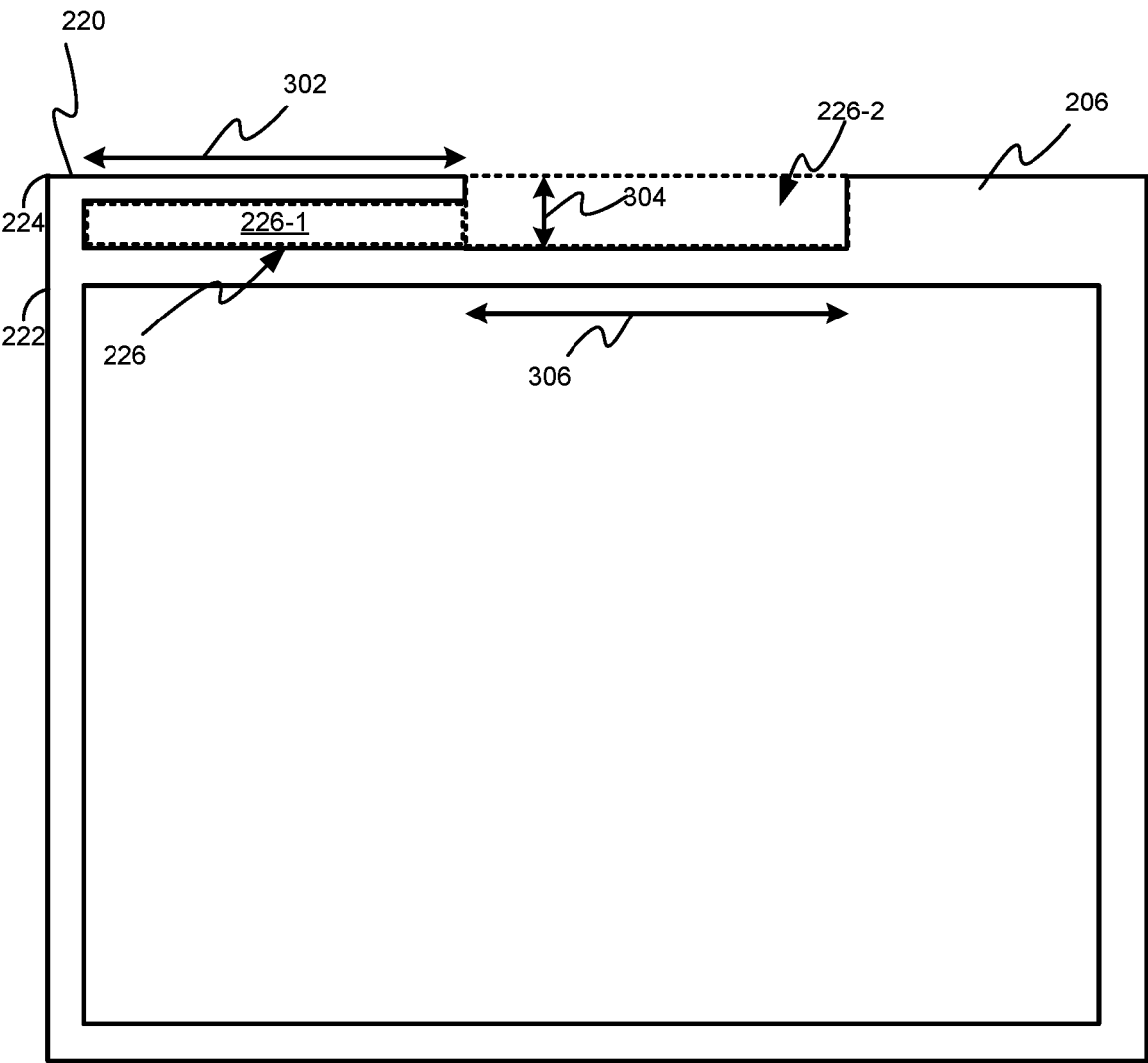


Figure 3

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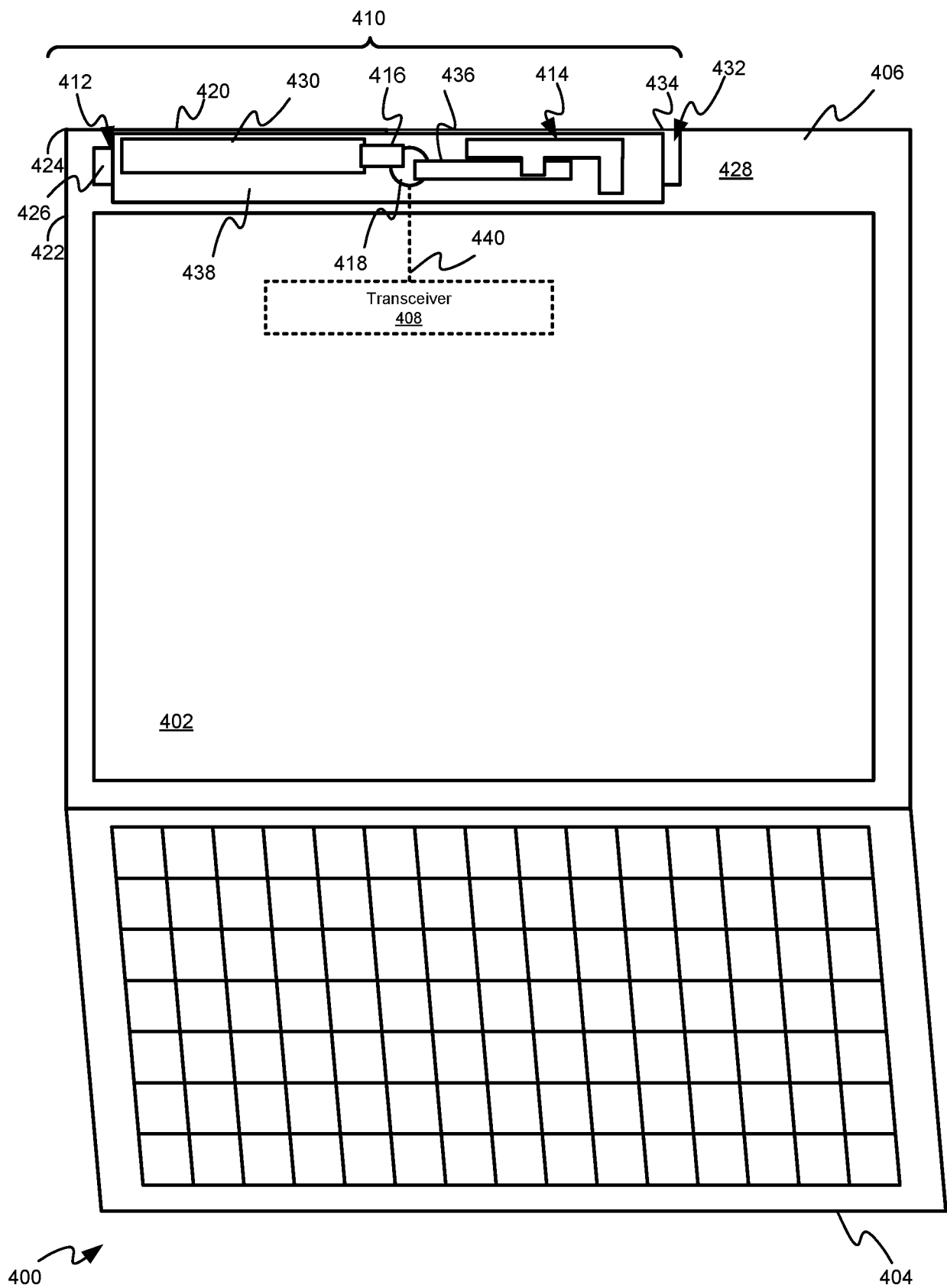


Figure 4

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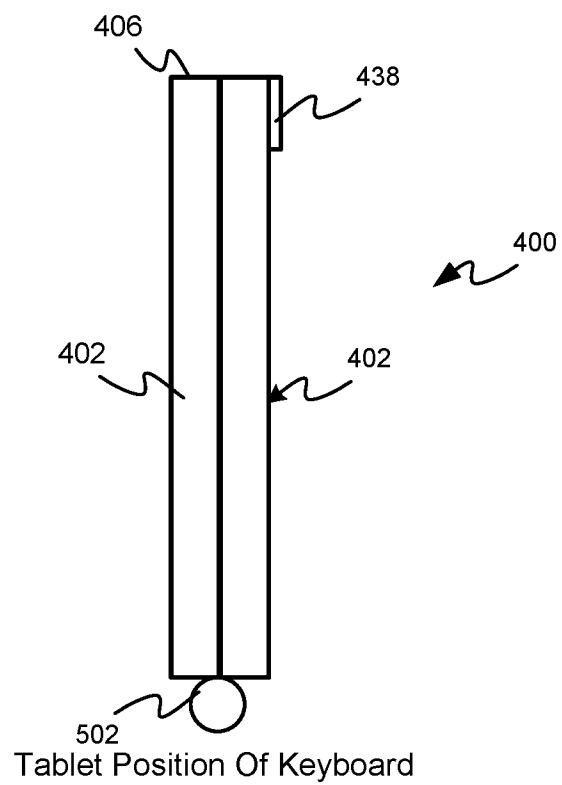
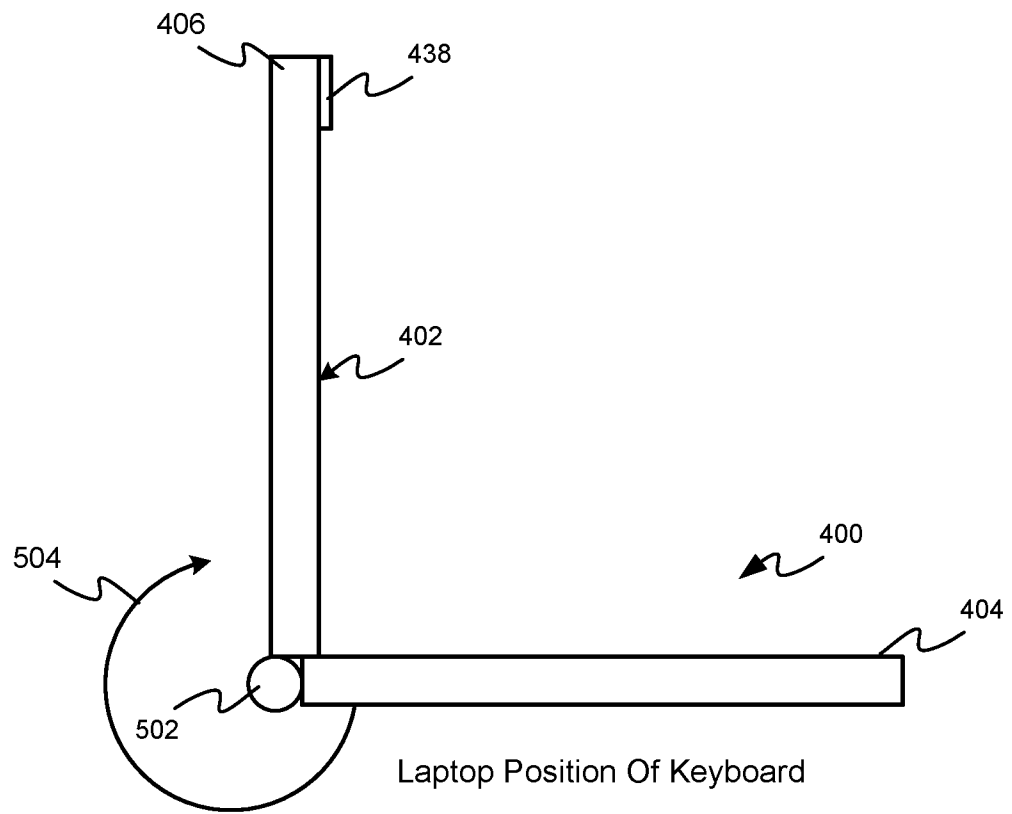


Figure 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2020/047717

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 5/00 (2015.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01Q 5/00, 9/00, 1/00-1/24

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)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010/0295737 A1 (ZLATOLJUB MILOSAVLJEVIC et al) 25.11.2010, abstract, fig. 3, 9, 10, par. [0026], [0027], [0030], [0041], [0042], [0044]	1-15
Y	US 2019/0097314 A1 (APPLE INC) 28.03.2019, fig. 4, par. [0053]	1-15
A	US 2012/0322393 A1 (PETER LINDBERG et al) 20.12.2012	1-15
A	EP 2113965 A1 (LAIRD TECHNOLOGIES AB) 04.11.2009	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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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

11 May 2021 (11.05.2021)

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