

| US 2021/0159587 A1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | '875 patent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
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| <p>1. A smartphone antenna module comprising:<br/> a flexible PCB comprising a sheet-like body with a first major surface and a second major surface facing away from the first major surface;<br/> the flexible PCB further comprising a first coil antenna, a second coil antenna and a third coil antenna formed in the sheet-like body between the first and second major surfaces;<br/> the first second and third coil antennas are located between a first and second edges of the flexible PCB the first coil antenna located between the first and second edges;<br/> the third coil antenna located between the first edge and the first coil antenna;<br/> the second coil antenna surrounding the first coil antenna when viewed in a thickness direction of the flexible PCB;<br/> the third coil antenna not overlapping the first coil antenna when viewed in the thickness direction,<br/> and a magnetic sheet attached to flexible PCB that overlaps entire portion of the first coil antenna,<br/> wherein no electric connection is formed between any two coil antennas of the first, second and third coil antennas in the flexible PCB;<br/> wherein the first coil antenna comprises an inner coil and an outer coil electrically connected to each other in parallel,<br/> wherein the inner coil has a wire width smaller than that of the outer coil,<br/> wherein the inner coil has the number of turns is greater than that of the outer coil,<br/> wherein the inner coil has a coil width is greater than that of the outer coil</p> | <p>1. A smartphone antenna module comprising:<br/> a substrate having a first major surface and a second major surface facing away from the first major surface;<br/> a first antenna pattern formed on the first major surface and comprising an inner coil and an outer coil surrounding the inner coil;<br/> a second antenna pattern formed on the second major surface and comprising an inner antenna pattern, and an outer antenna pattern;<br/> the inner antenna pattern comprising a plurality of concentric circular lines and defining a radially-extending inner gap into which the plurality of concentric circular lines of the inner antenna pattern does not extend, wherein at least part of the concentric circular lines of the inner antenna pattern overlaps the inner coil formed on the first major surface and is connected to the inner coil through vias;<br/> the outer antenna pattern comprising a plurality of concentric circular lines and defining a radially-extending outer gap into which the plurality of concentric circular lines of the outer antenna pattern does not extend, wherein at least part of the concentric circular lines of the outer antenna pattern overlaps the outer coil formed on the first major surface and is connected to the outer coil through vias;<br/> wherein at least part of the concentric circular lines of the outer antenna pattern generally surround at least part of the concentric circular lines of the inner antenna pattern,<br/> wherein the radially-extending outer gap and the radially-extending inner gap are connected and aligned in a direction;<br/> an inner extension line formed on the second major surface and extending through the radially-extending outer gap and further through at least part of the radially-extending inner gap;<br/> an outer extension line formed on the second major surface and extending through at least part of the radially-extending outer gap;<br/> two additional extension lines formed on the second major surface and extending through both the radially-extending inner gap and the radially-extending outer gap;<br/> wherein the inner extension line, the outer extension line and the two additional extension lines are extending generally in parallel; and<br/> wherein each of the inner extension line, the outer extension line, and the two additional extension lines formed on the second major surface comprises a portion that overlaps the outer coil formed on the first major surface.</p> <p>2. The smartphone antenna module of claim 1, wherein the inner extension line is electrically connected to a terminal of the inner coil, wherein at least part of the concentric circular</p> |

| US 2021/0159587 A1 | '875 patent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
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|                    | <p data-bbox="678 233 1243 262">lines of the inner antenna pattern is in a C shape.</p> <p data-bbox="678 300 1386 430">3. The smartphone antenna module of claim 1, wherein the outer extension line is electrically connected to a terminal of the outer coil, wherein at least part of the concentric circular lines of the outer antenna pattern is in a C shape.</p> <p data-bbox="678 468 1398 665">4. The smartphone antenna module of claim 1, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein each of the two additional extension lines is electrically connected to a terminal of the third antenna pattern.</p> <p data-bbox="678 703 1398 900">5. The smartphone antenna module of claim 1, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein at least one of the two additional extension lines contacts the third antenna pattern on the second major surface.</p> <p data-bbox="678 938 1365 1035">6. The smartphone antenna module of claim 1, wherein the inner coil and the outer coil are electrically connected in parallel.</p> <p data-bbox="678 1073 1386 1236">7. The smartphone antenna module of claim 1, wherein at least one of the inner extension line, the outer extension line, and the additional extension lines is electrically connected to the first antenna pattern formed on the first major surface through at least one via.</p> <p data-bbox="678 1274 1398 1572">8. The smartphone antenna module of claim 1, wherein the inner extension line is referred to as a first inner extension line and is electrically connected to a first terminal of the inner coil, wherein the smartphone antenna module further comprises a second inner extension line formed on the second major surface, wherein the second inner extension line is electrically connected to a second terminal of the inner coil and extends through at least part of the radially-extending outer gap.</p> <p data-bbox="678 1610 1377 1707">9. The smartphone antenna module of claim 1, wherein the inner coil includes a wire line having a width different from that of a wire line of the outer coil.</p> <p data-bbox="678 1745 1386 1875">10. The smartphone antenna module of claim 1, wherein the inner coil has a first number of turns, and the outer coil has a second number of turns, wherein the first number of turns is greater than the second number of turns.</p> |

| US 2021/0159587 A1 | '875 patent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
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|                    | <p>11. A smartphone comprising:<br/> a display module comprising a display surface;<br/> a rear cover comprising a rear surface facing away from the display surface;<br/> a battery placed between the display module and the rear cover; and<br/> the smartphone antenna module of claim 1 placed between the battery and the rear cover,<br/> wherein at least one of the inner coil and the outer coil are configured for wireless battery charging.</p> <p>12. The smartphone of claim 11, wherein the inner extension line is electrically connected to a terminal of the inner coil wherein at least part of the concentric circular lines of the inner antenna pattern is in a C shape.</p> <p>13. The smartphone of claim 11, wherein the outer extension line is electrically connected to a terminal of the outer coil, wherein at least part of the concentric circular lines of the outer antenna pattern is in a C shape.</p> <p>14. The smartphone of claim 11, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein each of the two additional extension lines is electrically connected to a terminal of the third antenna pattern.</p> <p>15. The smartphone of claim 11, wherein the second antenna pattern formed on the second major surface comprises a third antenna pattern generally surrounded by the inner antenna pattern, wherein at least one of the two additional extension lines contacts the third antenna pattern on the second major surface.</p> <p>16. The smartphone of claim 11, wherein the inner coil and the outer coil are electrically connected in parallel.</p> <p>17. The smartphone of claim 11, wherein at least one of the inner extension line, the outer extension line, and the additional extension lines is electrically connected to the first antenna pattern formed on the first major surface through at least one via.</p> <p>18. The smartphone of claim 11, wherein the inner extension line is referred to as a first inner extension line and is electrically connected to a first terminal of the inner coil, wherein the smartphone antenna module further comprises a</p> |

| US 2021/0159587 A1 | '875 patent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
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|                    | <p data-bbox="678 233 1372 401">second inner extension line formed on the second major surface, wherein the second inner extension line is electrically connected to a second terminal of the inner coil and extends through at least part of the radially-extending outer gap.</p> <p data-bbox="678 432 1372 531">19. The smartphone of claim 11, wherein the inner coil includes a wire line having a width different from that of a wire line of the outer coil.</p> <p data-bbox="678 562 1390 695">20. The smartphone of claim 11, wherein the inner coil has a first number of turns, and the outer coil has a second number of turns, wherein the first number of turns is greater than the second number of turns.</p> |