

SmartWitness AP1

Infringement where the main antenna is
considered the first antenna

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1

Geotab Exhibit 1047

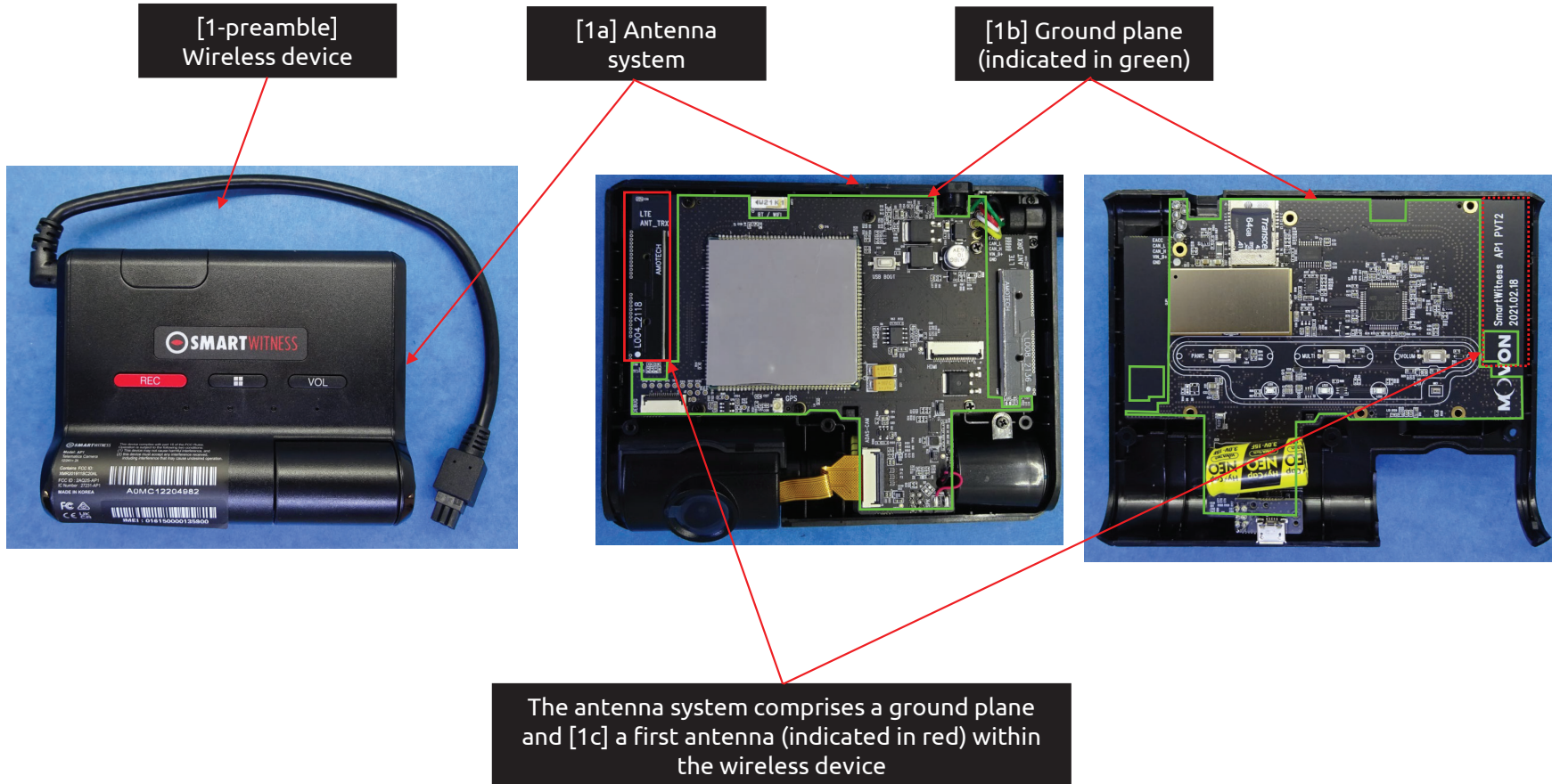
Geotab v. Fractus

~~CONFIDENTIAL - PROTECTIVE ORDER MATERIAL~~

US 11,031,677 - SmartWitness AP1

Claim 1

[1-preamble] A wireless device comprising:
[1a] an antenna system comprising:
[1b] a ground plane;
[1c] a first antenna within the wireless device and

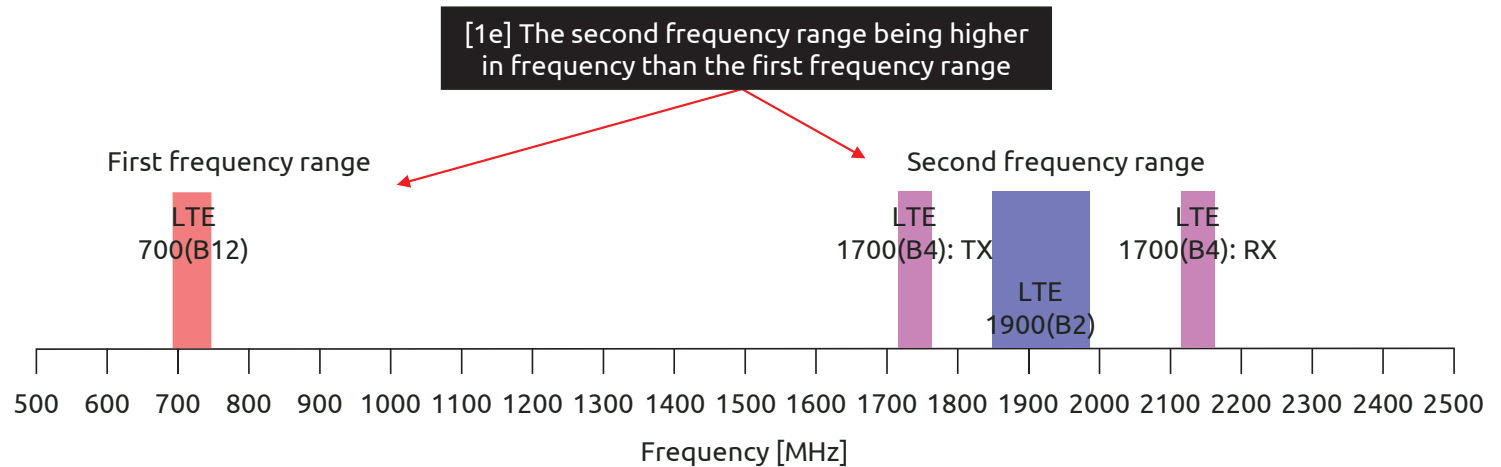


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Claim 1

[1d] configured to support at least three frequency bands contained within first and second frequency ranges of the electromagnetic spectrum, [1e] the second frequency range being higher in frequency than the first frequency range and [1f] at least one of the three frequency bands being associated with a 4G communication standard,



[1d] At least three frequency bands are contained within first (filled in red) and second frequency ranges (filled in blue) of the electromagnetic spectrum

[1f] At least one of the three frequency bands being associated with a 4G communication standard

Communications	
Antenna	LTE Main, LTE DRX, GNSS, Wi-Fi/BT
US	LTE CAT4: B2, B4, B5, B7, B12, B13, B25, B26 3G Bands: B1, B2, B5, B8
EMEA	LTE CAT4: B1, B2, B3, B5, B7, B8, B20, B28A 3G Bands: B1, B2, B5, B8
Wi-Fi	IEEE 802.11a/b/g/n
Bluetooth	BT4.2 (BR/EDR+BLE)

Source: device datasheet

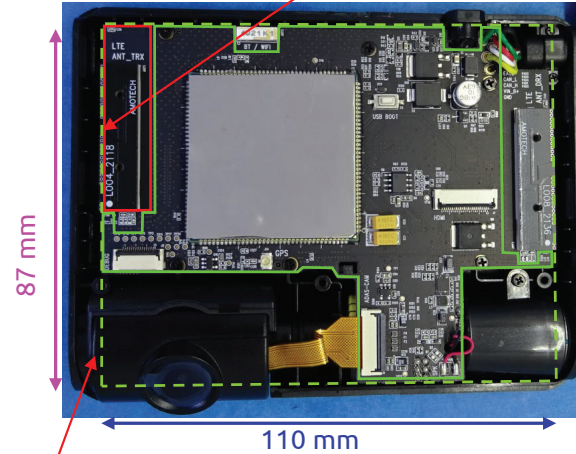
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Claim 1

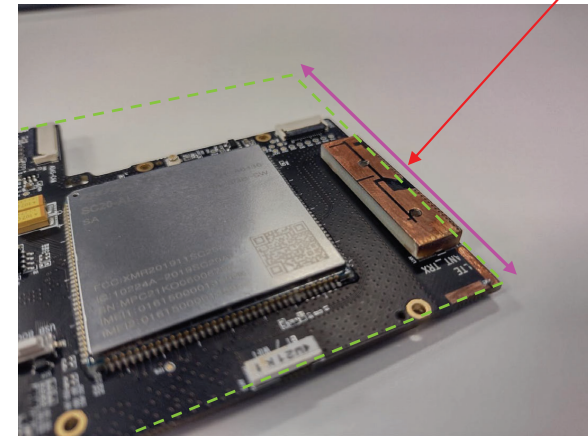
[1g] the first antenna being proximate to a first short side of a ground plane rectangle enclosing the ground plane and

[1g] The first antenna (indicated in red) is proximate to a first short side of a ground plane rectangle (indicated with a dashed green line) enclosing the ground plane



First short side (indicated in pink)

First short side (indicated in pink)

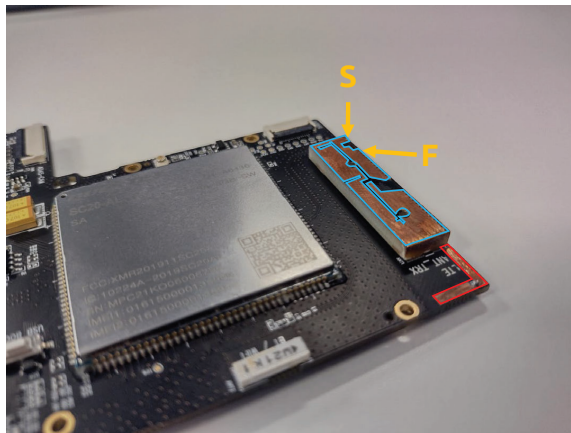


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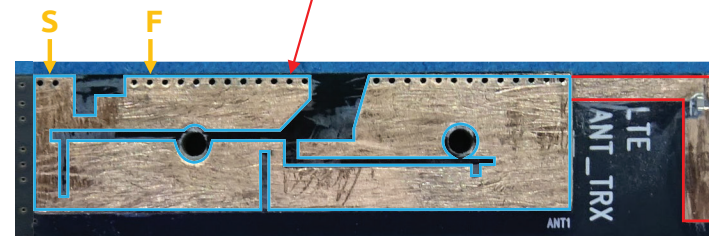
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Claim 1

[1h] defining a first antenna contour comprising an entire perimeter of the first antenna,



[1h] The first antenna defines a first antenna contour (indicated in blue and red) comprising an entire perimeter of the first antenna



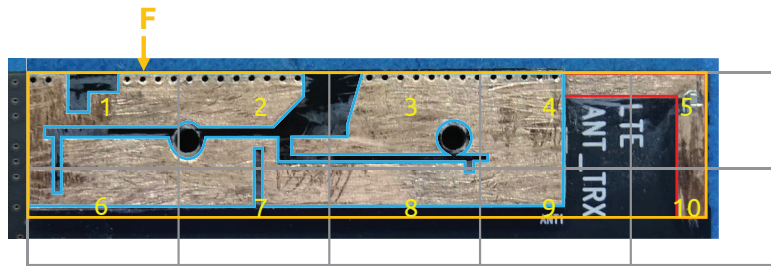
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Claim 1

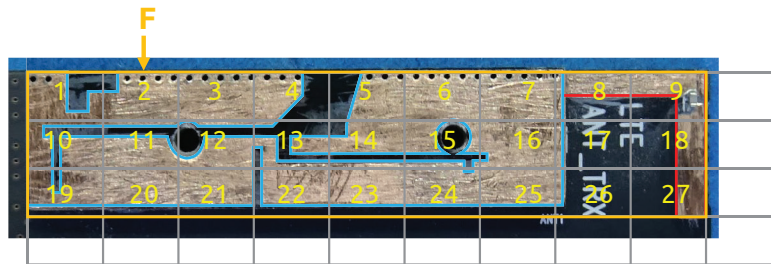
[1i] wherein the first antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and

[1i] The first antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20



$N_1 = 10$ cells

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(27/10)}{\log(2)} = 1.43 \geq 1.20$$



$N_2 = 27$ cells

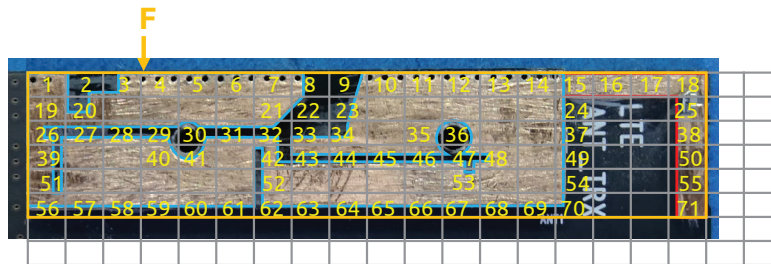
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Claim 1

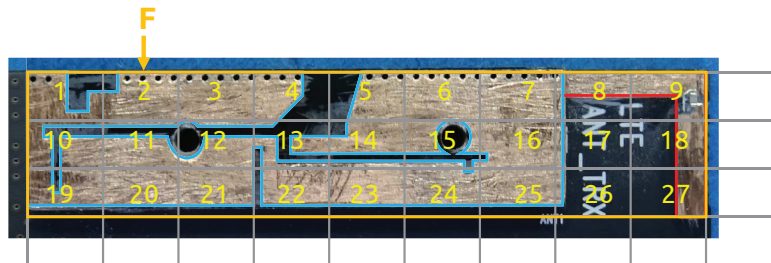
[1j] complexity factor F_{32} having a value less than 1.75; and

[1j] The first antenna contour has a level of complexity defined by complexity factor F_{32} having a value less than 1.75



$N_3 = 71 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(71/27)}{\log(2)} = 1.39 < 1.75$$



$N_2 = 27 \text{ cells}$

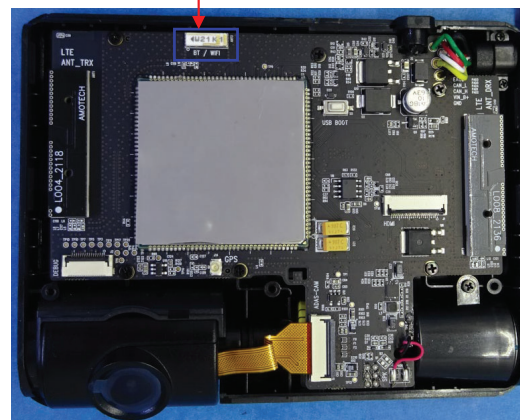
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Claim 1

[1k] a second antenna within the wireless device and

[1k] Second antenna (indicated in blue) within the wireless device



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Claim 1

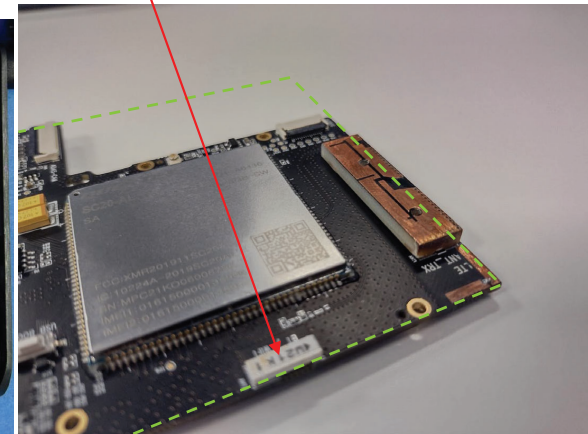
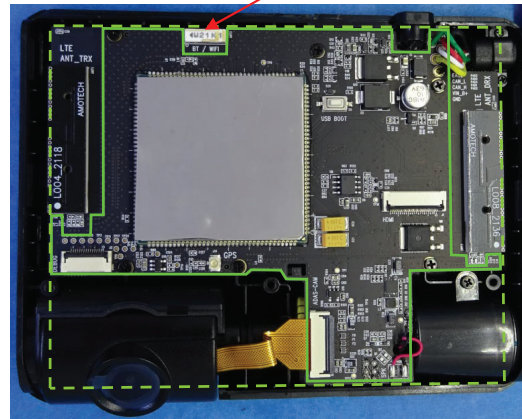
[1l] configured to support at least one frequency band different from the at least three frequency bands supported by the first antenna, [1m] the second antenna being arranged completely within the ground plane rectangle.

[1l] The second antenna is configured to support at least one frequency band (2.4 GHz) different from the at least three frequency bands supported by the first antenna

[1m] The second antenna is arranged completely within the ground plane rectangle

Communications	
Antenna	LTE Main, LTE DRX, GNSS, Wi-Fi/BT
US	LTE CAT4: B2, B4, B5, B7, B12, B13, B25, B26 3G Bands: B1, B2, B5, B8
EMEA	LTE CAT4: B1, B2, B3, B5, B7, B8, B20, B28A 3G Bands: B1, B2, B5, B8
Wireless	Wi-Fi: IEEE 802.11a/b/g/n Bluetooth: BT4.2 (BR/EDR+BLE)

Source: device datasheet

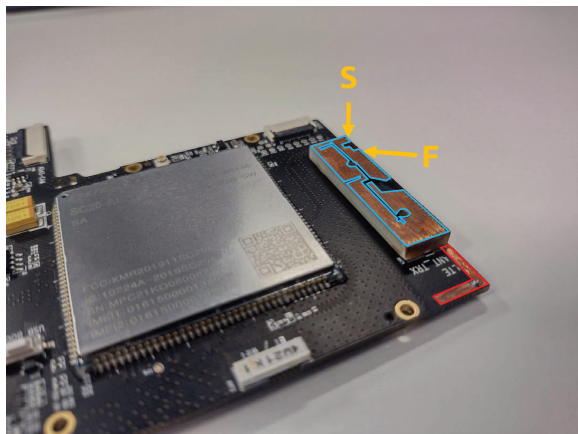


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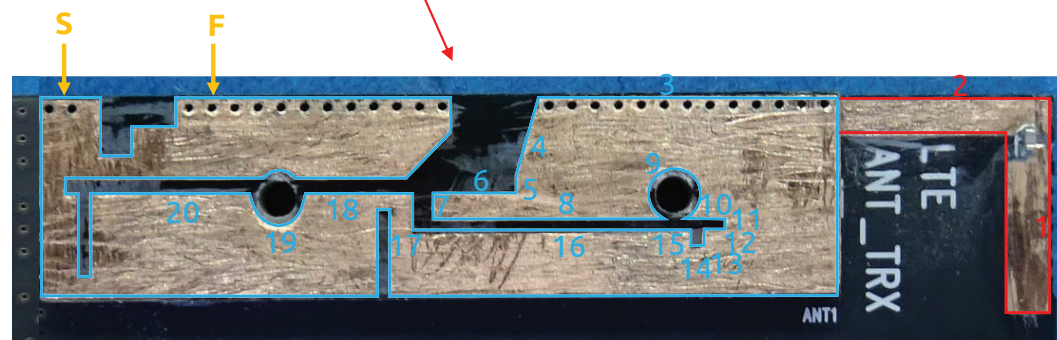
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Claim 2

[2a] The wireless device of claim 1, wherein the first antenna contour comprises at least 20 segments.



[2a] The first antenna contour (indicated in blue and red) comprises at least 20 segments



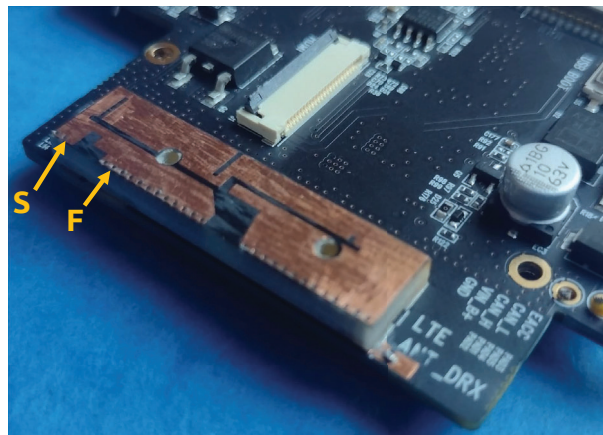
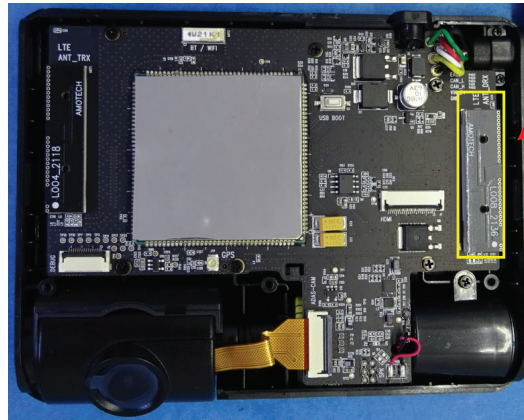
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Claim 4

[4a] The wireless device of claim 1, wherein the antenna system comprises a third antenna configured to receive signals employing a 4G communication standard.

[4a] The antenna system comprises a third antenna (indicated in yellow) configured to receive signals employing a 4G communication standard



Communications	
Antenna	LTE Main, LTE DRX, GNSS, Wi-Fi/BT
US	LTE CAT4: B2, B4, B5, B7, B12, B13, B25, B26 3G Bands: B1, B2, B5, B8
Wireless	EMEA LTE CAT4: B1, B2, B3, B5, B7, B8, B20, B28A 3G Bands: B1, B2, B5, B8
	Wi-Fi: IEEE 802.11a/b/g/n
	Bluetooth: BT4.2 (BR/EDR+BLE)

Source: device datasheet

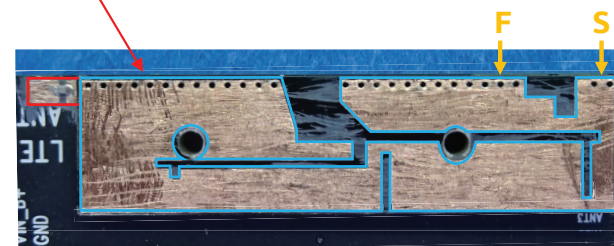
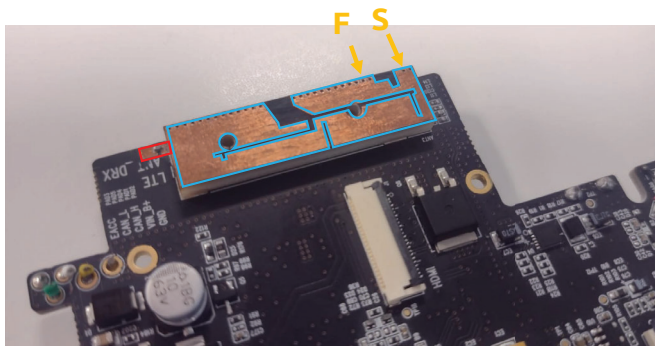
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Claim 5

[5a] The wireless device of claim 4, wherein the third antenna defines an antenna contour comprising an entire perimeter of the third antenna, and

[5a] The third antenna defines an antenna contour (indicated in blue and red) comprising an entire perimeter of the third antenna



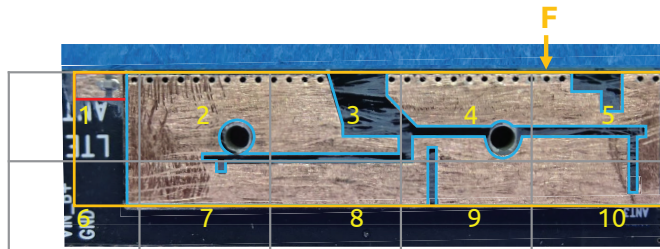
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Claim 5

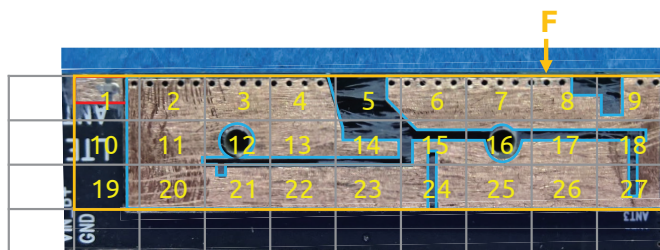
[5b] wherein the antenna contour of the third antenna has a level of complexity defined by complexity factor F_{21} having a value of at least 1.2 and

[5b] The antenna contour of the third antenna has a level of complexity defined by complexity factor F_{21} having a value of at least 1.2



$N_1 = 10 \text{ cells}$

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(27/10)}{\log(2)} = 1.43 \geq 1.20$$



$N_2 = 27 \text{ cells}$

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Claim 5

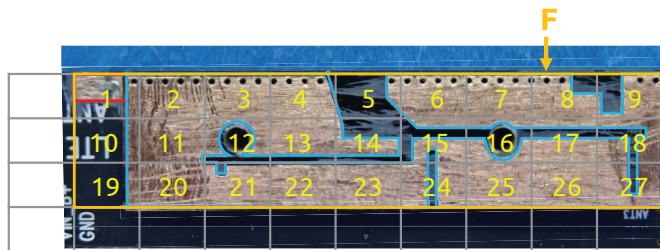
[5c] a complexity factor F_{32} having a value of at least 1.35.

[5c] The antenna contour of the third antenna has a level of complexity defined by complexity factor F_{32} having a value of at least 1.35



$N_3 = 72 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(72/27)}{\log(2)} = 1.42 \geq 1.35$$



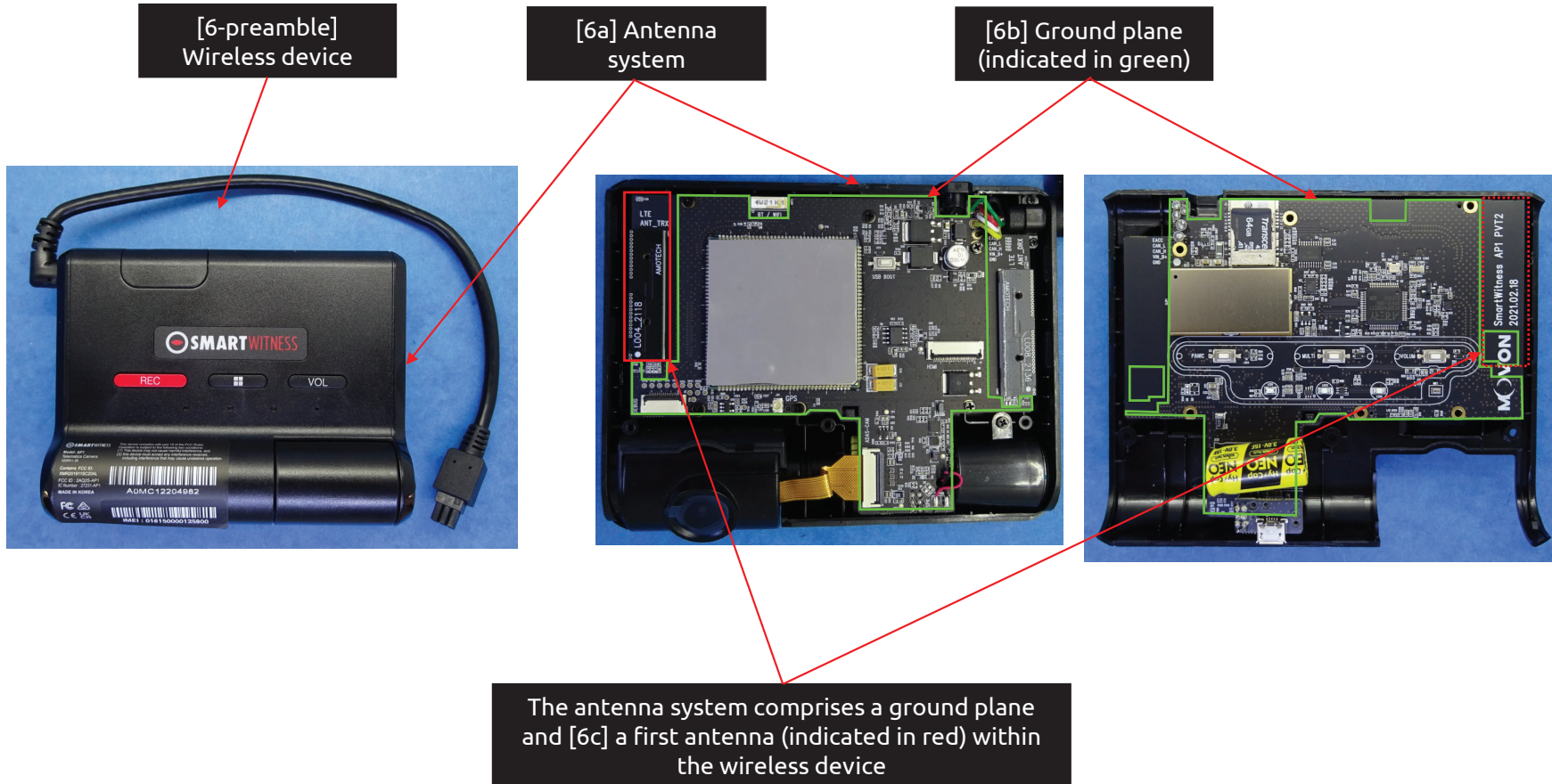
$N_2 = 27 \text{ cells}$

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Claim 6

[6-preamble] A wireless device comprising:
[6a] an antenna system comprising:
[6b] a ground plane;
[6c] a first antenna within the wireless device and

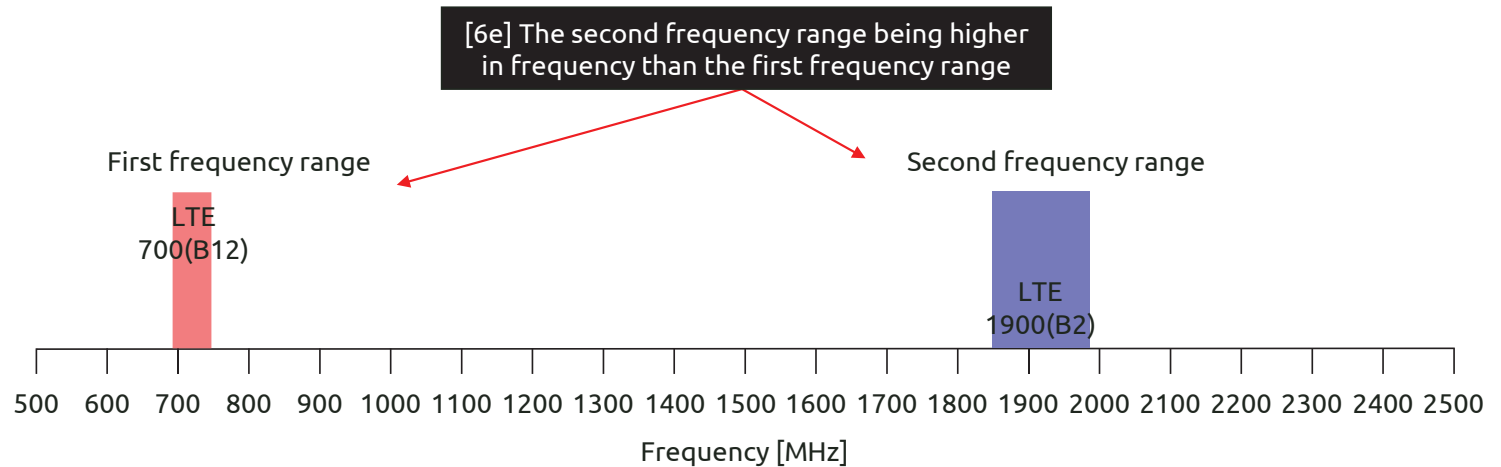


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Claim 6

[6d] configured to support at least two frequency bands contained within first and second frequency ranges of the electromagnetic spectrum, [6e] the second frequency range being higher in frequency than the first frequency range,



[6e] The second frequency range being higher in frequency than the first frequency range

[6d] At least two frequency bands are contained within first (filled in red) and second frequency ranges (filled in blue) of the electromagnetic spectrum

Communications	
Antenna	LTE Main, LTE DTX, GNSS, Wi-Fi, BT
US	LTE CAT4: B2, B4, B5, B7, B12, B13, B25, B26 3G Bands: B1, B2, B5, B8
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Wireless	Wi-Fi: IEEE 802.11a/b/g/n Bluetooth: BT4.2 (BR/EDR+BLE)

Source: device datasheet

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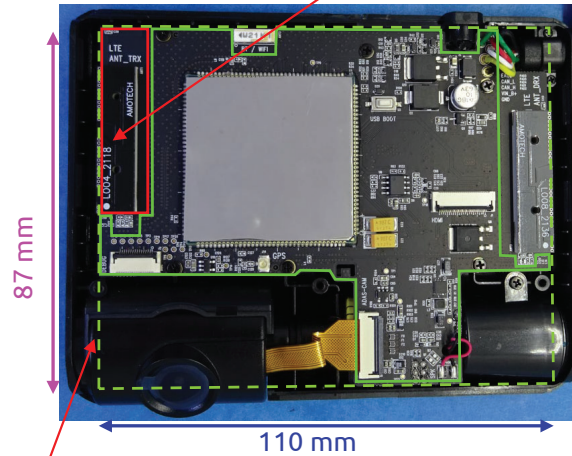
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Claim 6

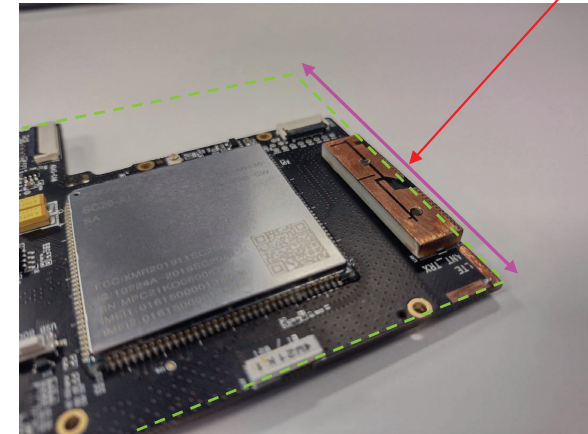
[6f] the first antenna being proximate to a first short side of a first short side of a ground plane rectangle enclosing the ground plane and

[6f] The first antenna (indicated in red) is proximate to a first short side of a ground plane rectangle (indicated with a dashed green line) enclosing the ground plane

First short side (indicated in pink)



First short side (indicated in pink)

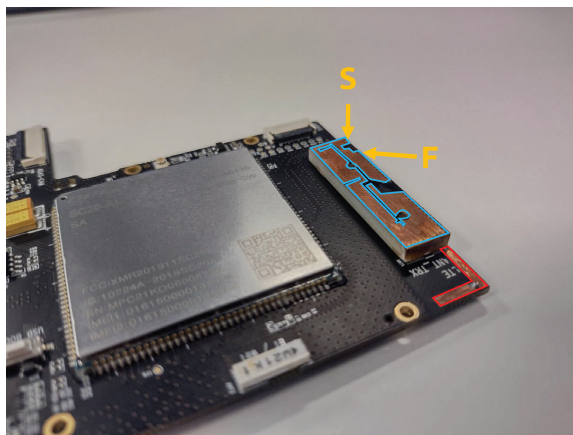


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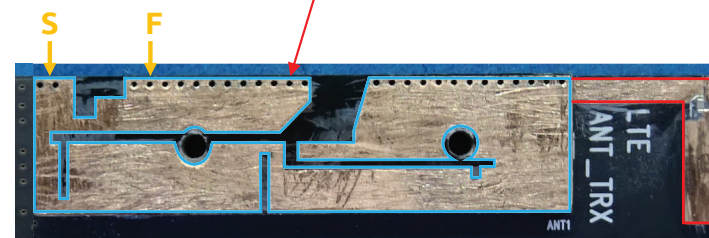
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Claim 6

[6g] defining a first antenna contour comprising an entire perimeter of the first antenna,



[6g] The first antenna defines a first antenna contour (indicated in blue and red) comprising an entire perimeter of the first antenna



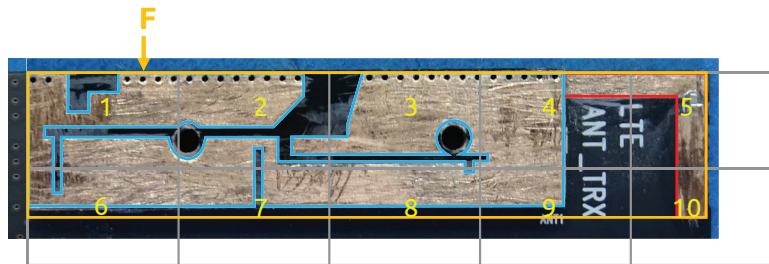
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Claim 6

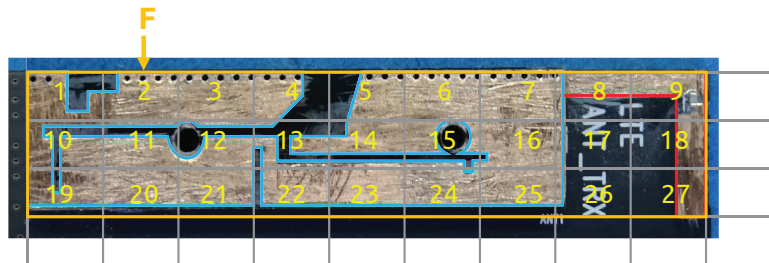
[6h] wherein the first antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and

[6h] The first antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20



$N_1 = 10$ cells

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(27/10)}{\log(2)} = 1.43 \geq 1.20$$



$N_2 = 27$ cells

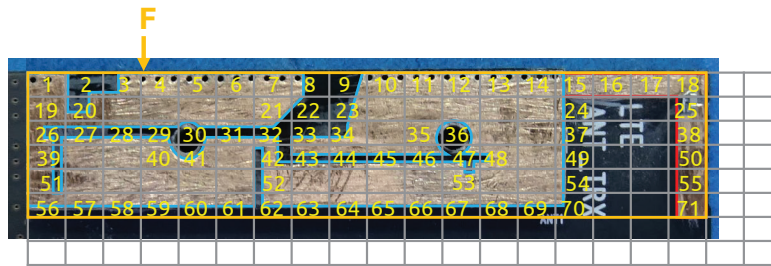
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Claim 6

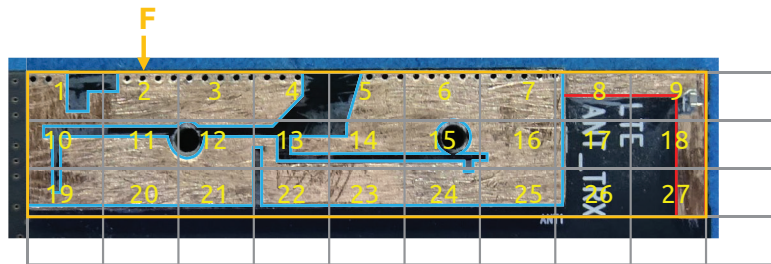
[6i] complexity factor F_{32} having a value less than 1.75; and

[6i] The first antenna contour has a level of complexity defined by complexity factor F_{32} having a value less than 1.75



$N_3 = 71$ cells

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(71/27)}{\log(2)} = 1.39 < 1.75$$



$N_2 = 27$ cells

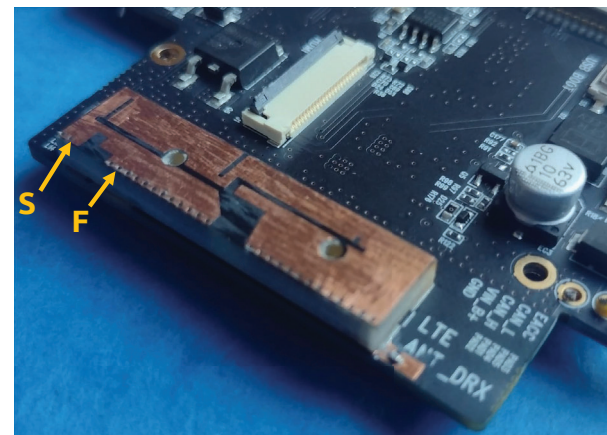
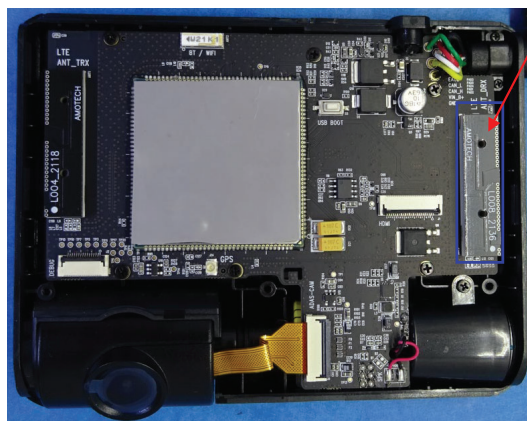
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Claim 6

[6j] a second antenna within the wireless device and

[6j] Second antenna (indicated in blue) within the wireless device



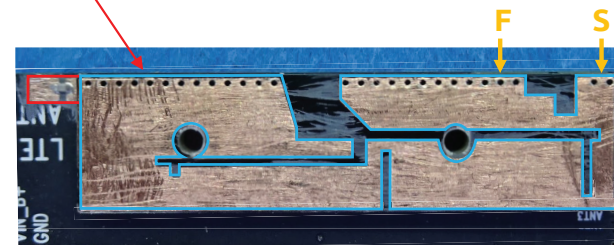
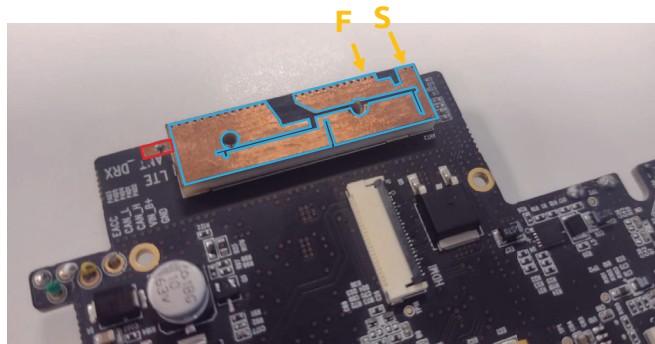
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Claim 6

[6k] defining a second antenna contour comprising an entire perimeter of the second antenna,

[6k] The second antenna defines a second antenna contour (indicated in blue and red) comprising an entire perimeter of the second antenna



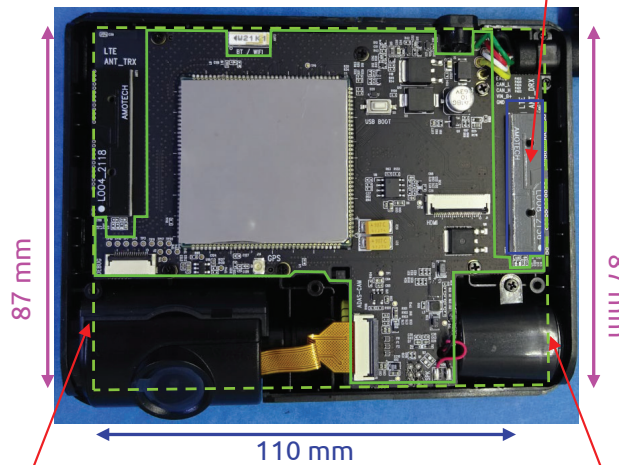
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Claim 6

[6l] the second antenna being proximate to a second short side of the ground plane rectangle that is opposite to the first short side of the ground plane rectangle,

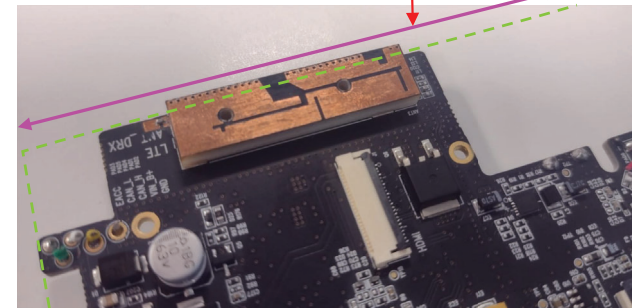
[6l] The second antenna (indicated in blue) being proximate to a second short side of the ground plane rectangle that is opposite to the first short side of the ground plane rectangle



First short side (indicated in pink)

Second short side (indicated in pink)

Second short side (indicated in pink)



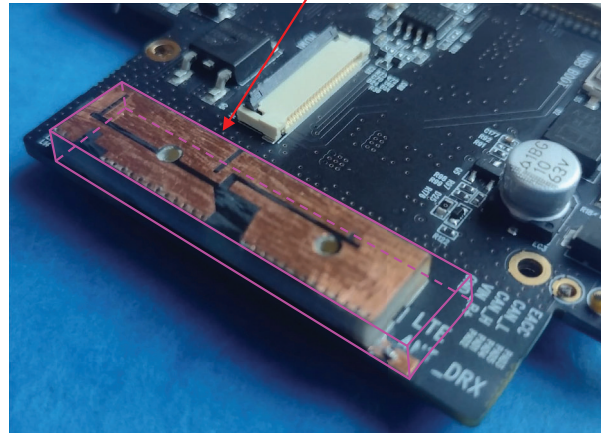
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Claim 6

[6m] a minimum-sized parallelepiped of rectangular faces that completely encloses a volume of the second antenna defining an antenna box, and

[6m] A minimum-sized parallelepiped of rectangular faces that completely encloses a volume of the second antenna defining an antenna box (outlined in pink)



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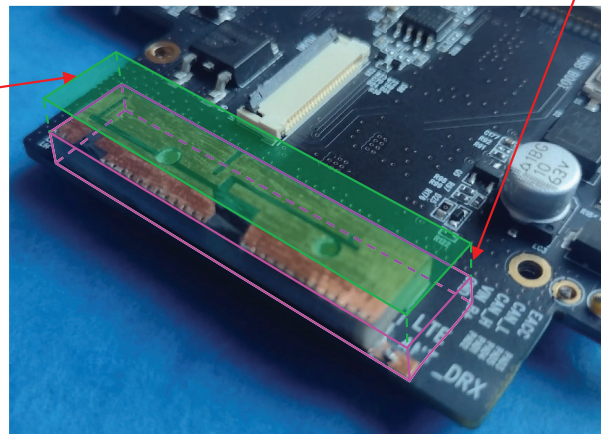
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Claim 6

[6n] an orthogonal projection of the antenna box along a normal to a face with a largest area of the second antenna defining [6o] an antenna rectangle,

[6o] Antenna rectangle (filled in green)

[6n] An orthogonal projection of the antenna box along a normal to a face* with a largest area of the second antenna



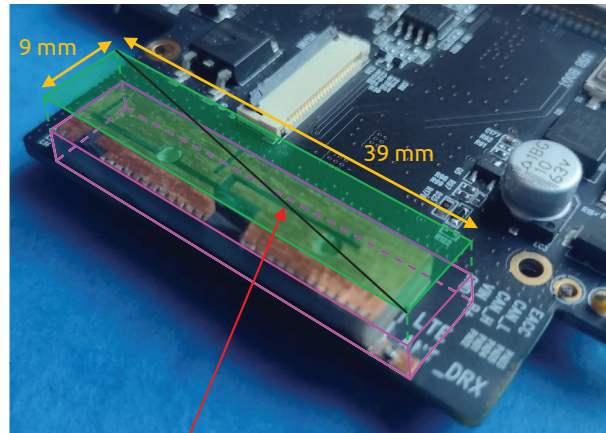
*Normal to a face means perpendicular to the face

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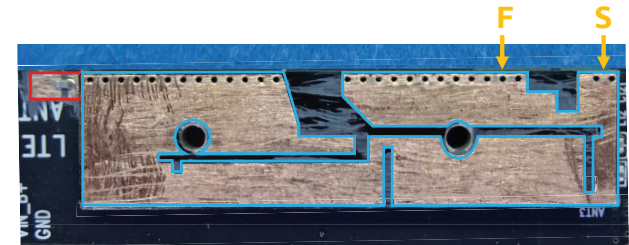
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Claim 6

[6p] wherein a length of the second antenna contour is greater than four times a diagonal of the antenna rectangle.



Diagonal of the antenna rectangle = 40.02 mm



182.3 mm

9.6 mm

Length of the second antenna contour = $(182.3 + 9.6) = 191.9$ mm

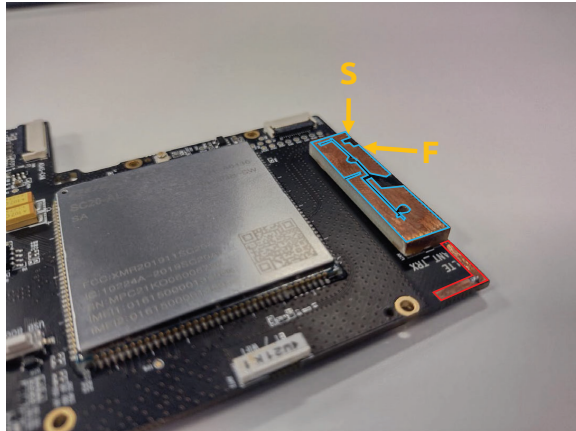
[6p] The length of the second antenna contour (191.9 mm) > 4*Diagonal of the antenna rectangle (4*40.02 = 160.08 mm)

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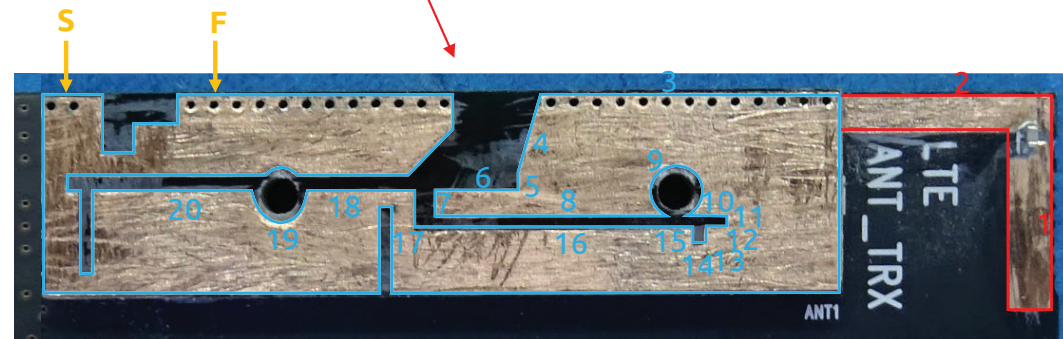
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Claim 7

[7a] The wireless device of claim 6, wherein the first antenna contour comprises at least 20 segments.



[7a] The first antenna contour (indicated in blue and red) comprises at least 20 segments

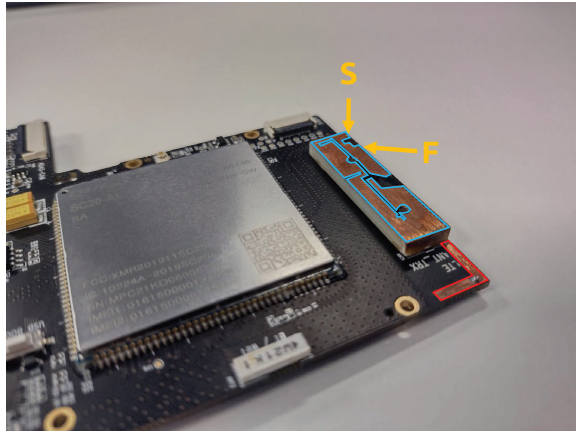


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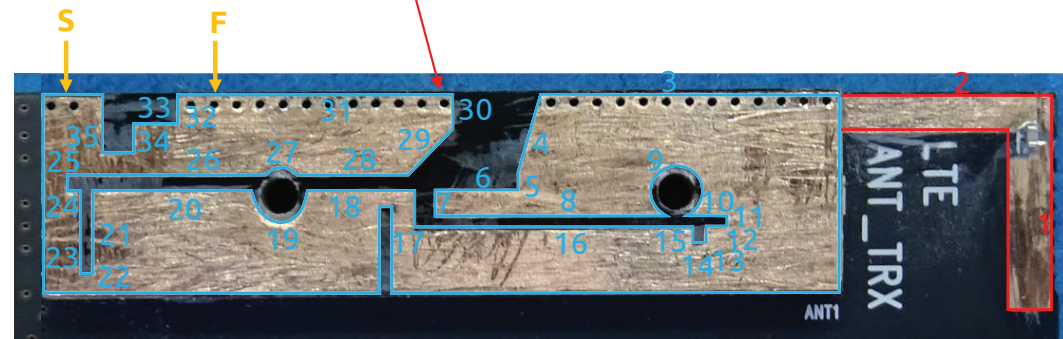
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Claim 8

[8a] The wireless device of claim 7, wherein the first antenna contour comprises at least 35 segments.



[8a] The first antenna contour (indicated in blue and red) comprises at least 35 segments



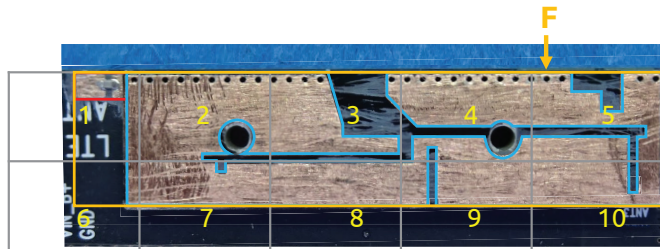
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Claim 9

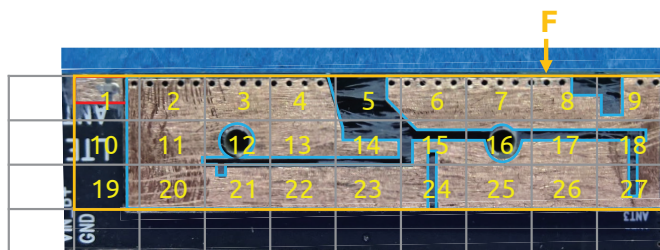
[9a] The wireless device of claim 6, wherein the second antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.2 and

[9a] The second antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20



$N_1 = 10 \text{ cells}$

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(27/10)}{\log(2)} = 1.43 \geq 1.20$$



$N_2 = 27 \text{ cells}$

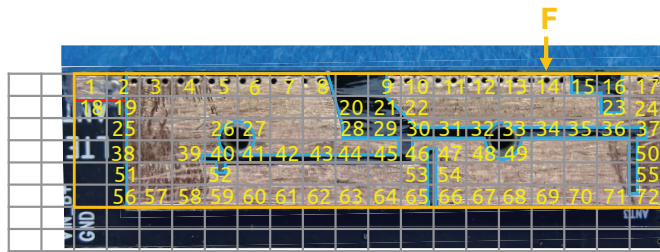
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Claim 9

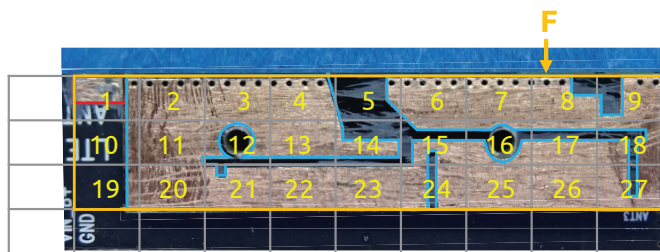
[9b] a complexity factor F_{32} having a value of at least 1.35.

[9b] The second antenna contour has a level of complexity defined by complexity factor F_{32} having a value of at least 1.35



$N_3 = 72 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(72/27)}{\log(2)} = 1.42 \geq 1.35$$



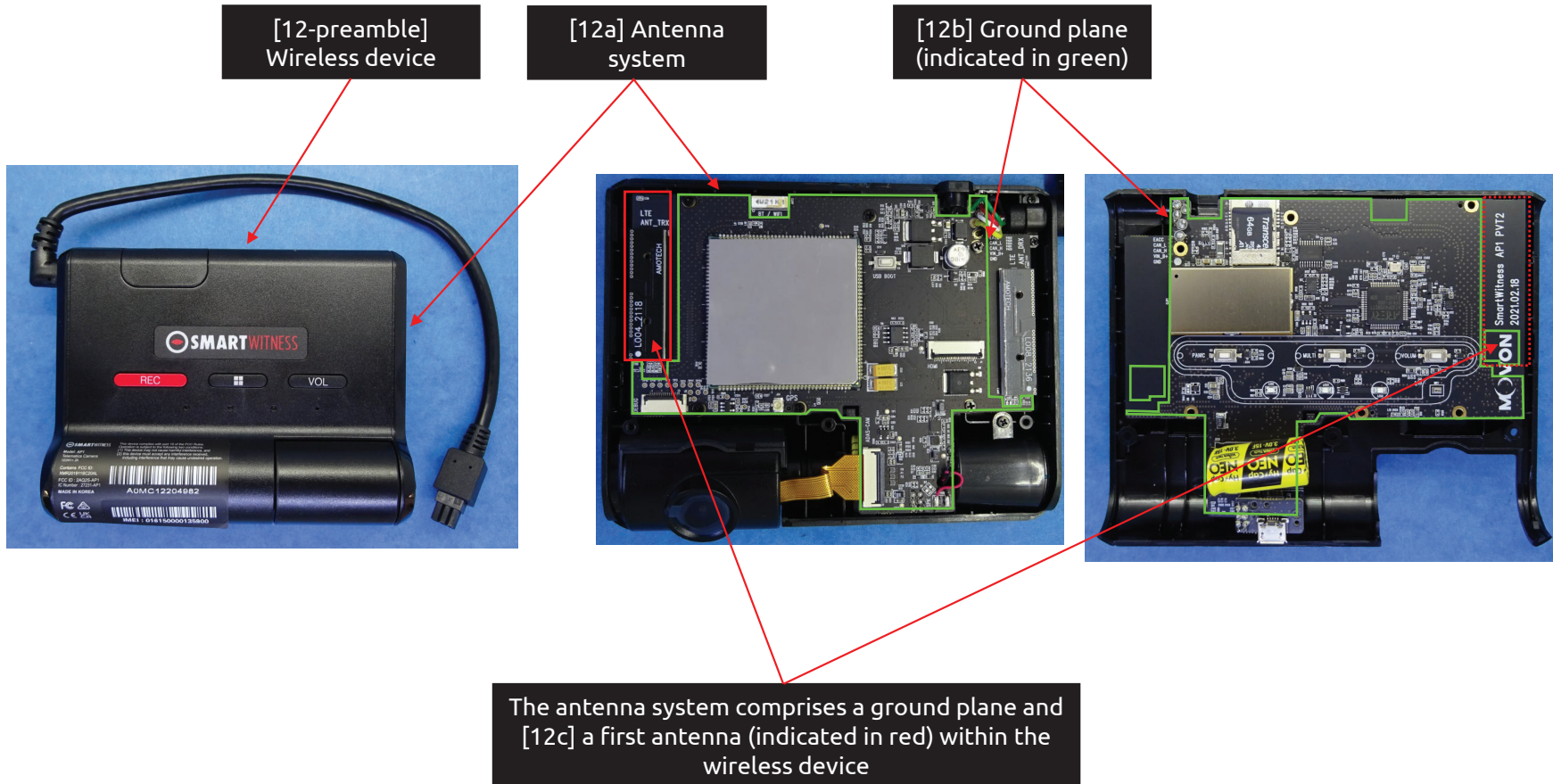
$N_2 = 27 \text{ cells}$

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Claim 12

[12-preamble] A wireless device comprising:
[12a] an antenna system comprising:
[12b] a ground plane;
[12c] a first antenna within the wireless device and

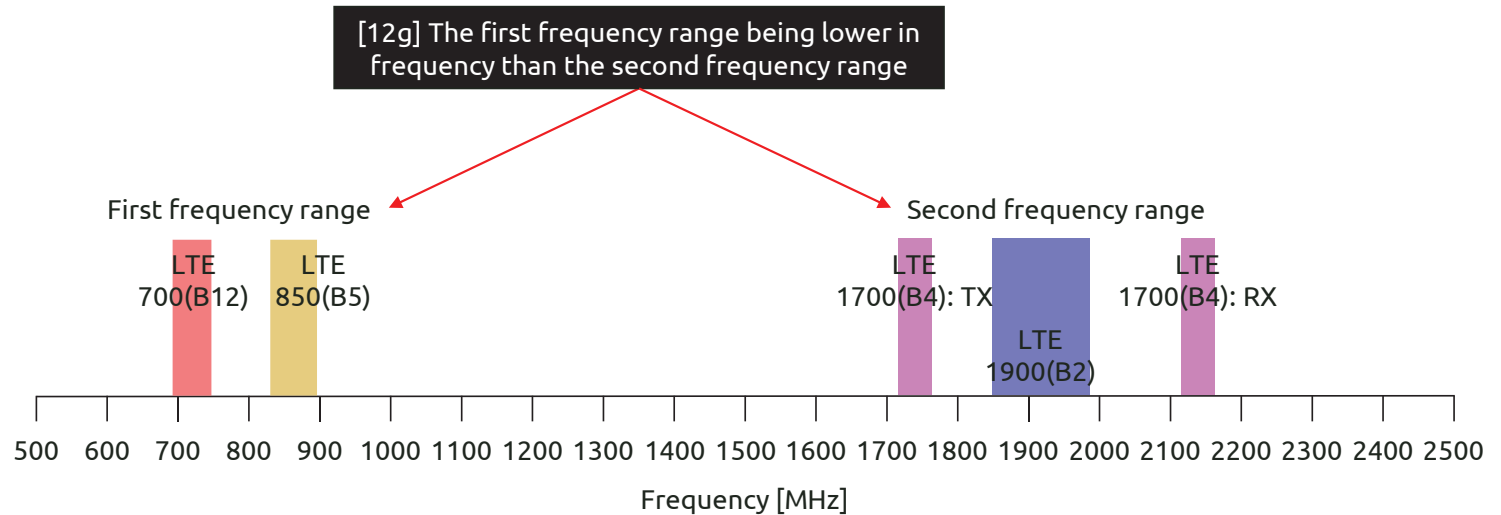


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Claim 12

[12d] configured to provide operation in at least four frequency bands, [12e] at least one of the at least four frequency bands is contained within a first frequency range and [12f] at least one other of the four frequency bands is contained within a second frequency range, [12g] the first frequency range being lower in frequency than the second frequency range,



[12d] First antenna is configured to provide operation in at least four frequency bands

[12e] At least one of the at least four frequency bands (filled in red) is contained within a first frequency range and [12f] at least one other of the four frequency bands (filled in blue) is contained within a second frequency range

Communications	
Antenna	LTE Main, LTE DRX, GNSS, Wi-Fi/BT
US	LTE CAT4: B2, B4, B5, B7, B12, B13, B25, B26 3G Bands: B1, B2, B5, B8
EMEA	LTE CAT4: B1, B2, B3, B5, B7, B8, B20, B28A 3G Bands: B1, B2, B5, B8
Wi-Fi:	IEEE 802.11a/b/g/n
Bluetooth:	BT4.2 (BR/EDR+BLE)

Source: device datasheet

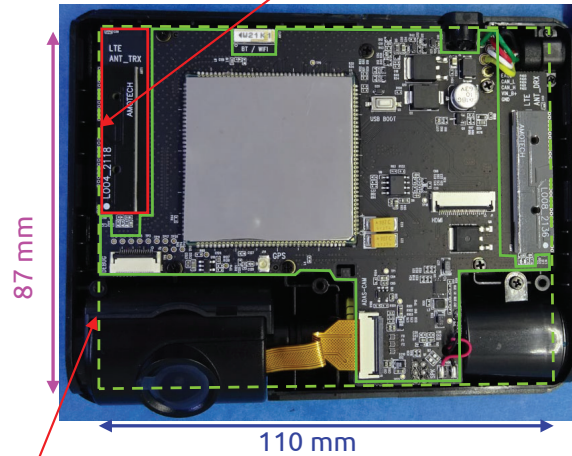
CONFIDENTIAL

US 11,031,677 - SmartWitness AP1

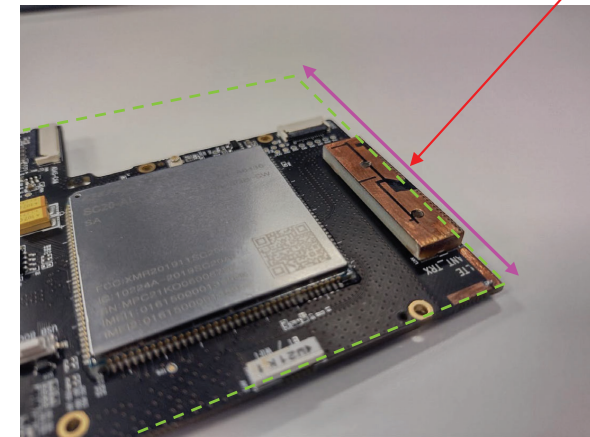
Claim 12

[12h] the first antenna being proximate to a first short side of a ground plane rectangle enclosing the ground plane,

[12h] The first antenna (indicated in red) being proximate to a first short side of a ground plane rectangle (indicated with a dashed green line) enclosing the ground plane



First short side (indicated in pink)



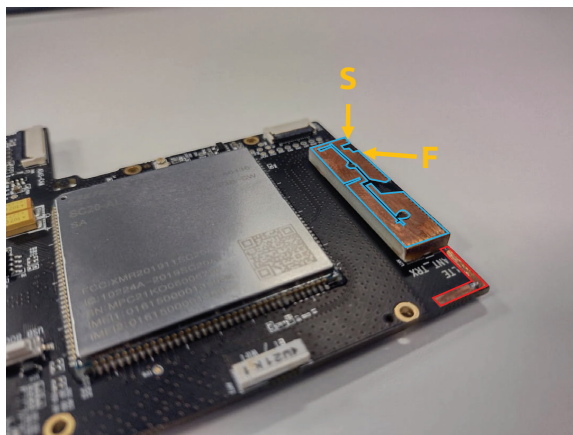
First short side (indicated in pink)

CONFIDENTIAL

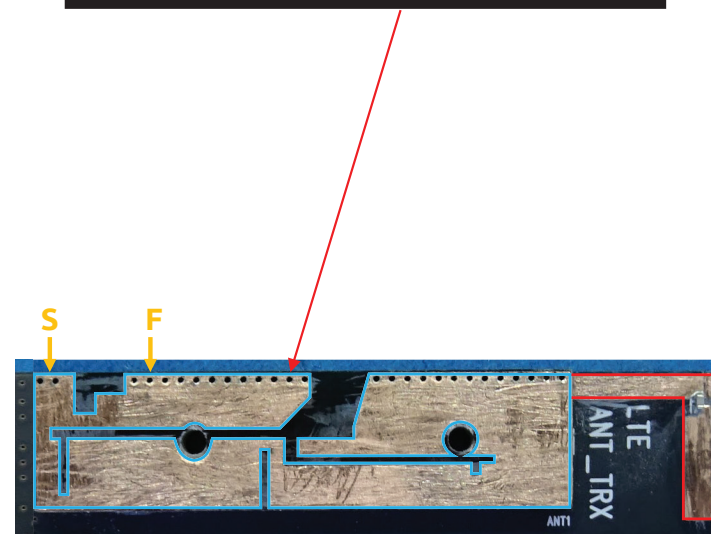
US 11,031,677 - SmartWitness AP1

Claim 12

[12i] the first antenna defining a first antenna contour comprising an entire perimeter of the first antenna, and



[12i] The first antenna defines a first antenna contour (indicated in blue and red) comprising an entire perimeter of the first antenna



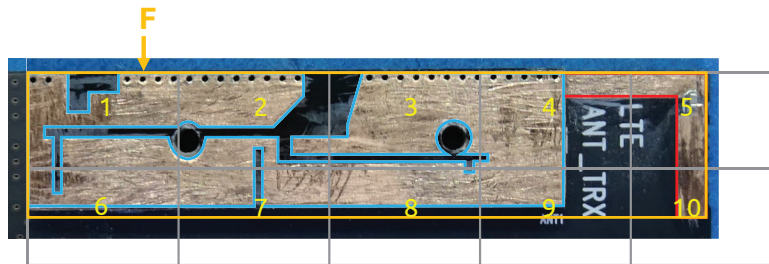
CONFIDENTIAL

US 11,031,677 - SmartWitness AP1

Claim 12

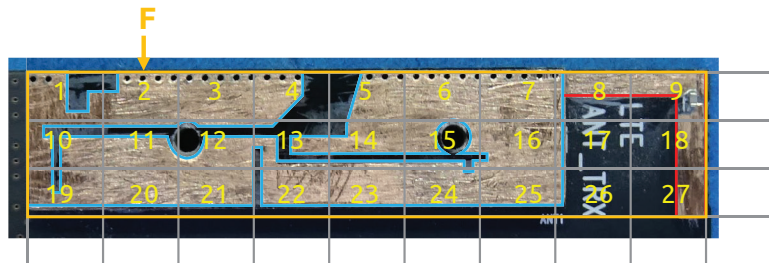
[12j] wherein the first antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and

[12j] The first antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20



$N_1 = 10 \text{ cells}$

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(27/10)}{\log(2)} = 1.43 \geq 1.20$$



$N_2 = 27 \text{ cells}$

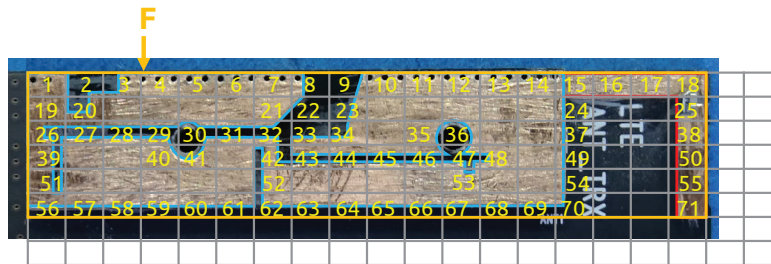
CONFIDENTIAL

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Claim 12

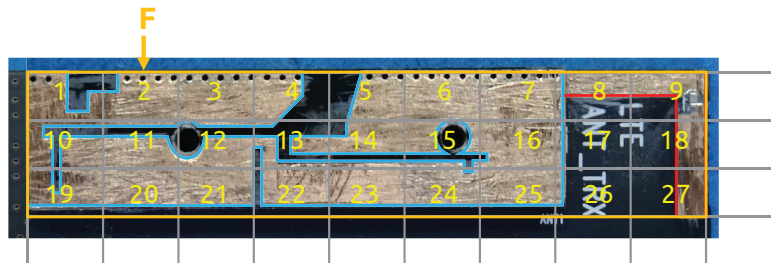
[12k] complexity factor F_{32} having a value less than 1.75; and

[12k] The first antenna contour has a level of complexity defined by complexity factor F_{32} having a value less than 1.75



$N_3 = 71$ cells

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(71/27)}{\log(2)} = 1.39 < 1.75$$



$N_2 = 27$ cells

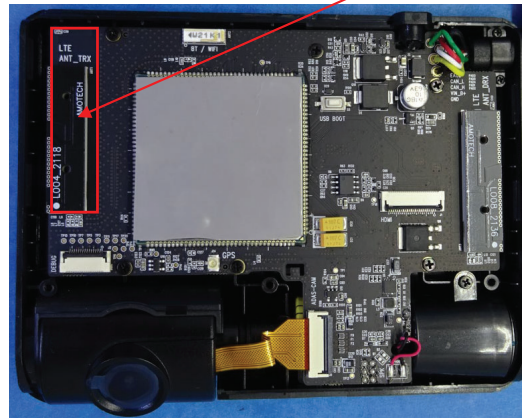
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Claim 12

[12l] wherein the first antenna is configured to transmit and receive signals from a 4G communication standard; and

[12l] The first antenna is configured to transmit and receive signals from a 4G communication standard



Communications

Antenna	LTE Main, LTE DTX, GNSS, Wi-Fi/BT
US	LTE CAT4: B2, B4, B5, B7, B12, B13, B25, B26 3G Bands: B1, B2, B5, B8
EMEA	LTE CAT4: B1, B2, B3, B5, B7, B8, B20, B28A 3G Bands: B1, B2, B5, B8
Wireless	Wi-Fi: IEEE 802.11a/b/g/n Bluetooth: BT4.2 (BR/EDR+BLE)

Source: device datasheet

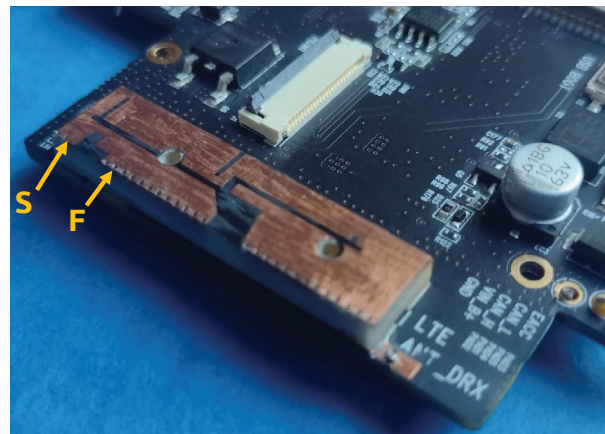
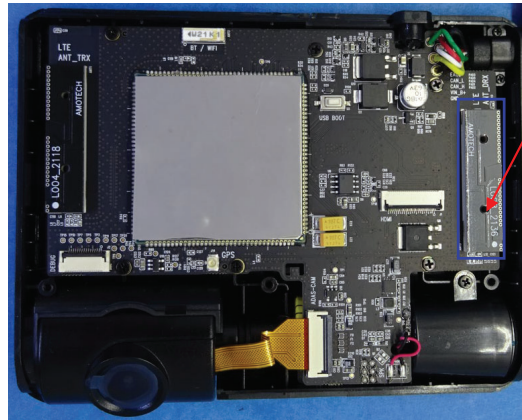
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Claim 12

[12m] a second antenna within the wireless device and configured to receive signals from a 4G communication standard,

[12m] Second antenna (indicated in blue) within the wireless device and configured to receive signals employing a 4G communication standard



Communications

Antenna	LTE MIMO, LTE DRX, GNSS, Wi-Fi/BT
US	LTE CAT4: B2, B4, B5, B7, B12, B13, B25, B26 3G Bands: B1, B2, B5, B8
EMEA	LTE CAT4: B1, B2, B3, B5, B7, B8, B20, B28A 3G Bands: B1, B2, B5, B8
Wireless	Wi-Fi: IEEE 802.11a/b/g/n Bluetooth: BT4.2 (BR/EDR+BLE)

Source: device datasheet

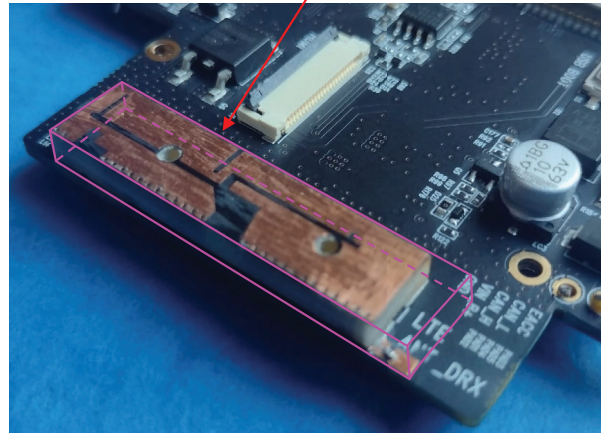
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Claim 12

[12n] a minimum-sized parallelepiped of rectangular faces that completely encloses a volume of the second antenna defining an antenna box,

[12n] A minimum-sized parallelepiped of rectangular faces that completely encloses a volume of the second antenna defining an antenna box (outlined in pink)



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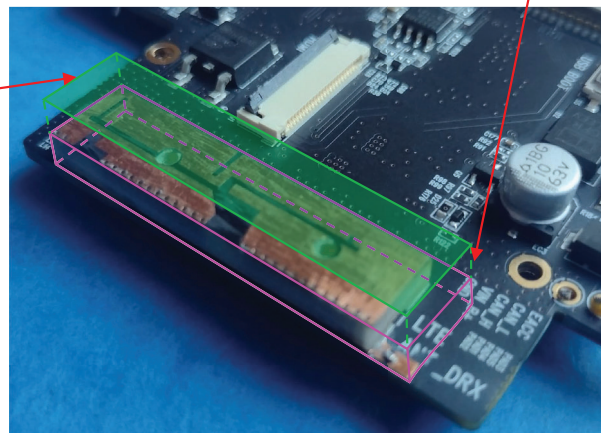
US 11,031,677 - SmartWitness AP1

Claim 12

[12o] an orthogonal projection of the antenna box along a normal to a face with a largest area of the second antenna defining [12p] an antenna rectangle,

[12p] Antenna rectangle (filled in green)

[12o] An orthogonal projection of the antenna box along a normal to a face* with a largest area of the second antenna



*Normal to a face means perpendicular to the face

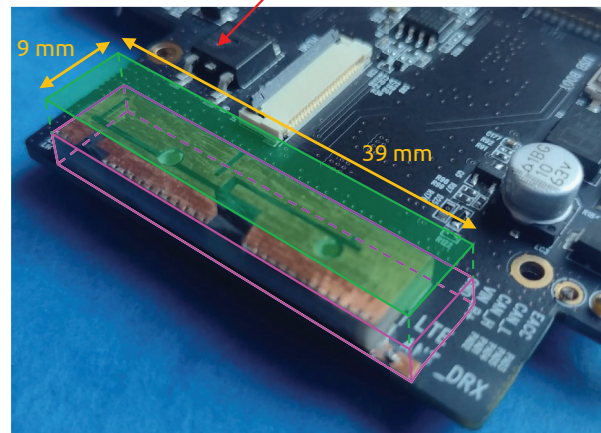
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Claim 12

[12q] an aspect ratio of the antenna rectangle being defined as a ratio between a width and a height of the antenna rectangle, and wherein the aspect ratio has a value of at least 2.

[12q] Aspect ratio of the antenna rectangle being defined as a ratio between a width and a height of the antenna rectangle, and wherein the aspect ratio has a value of $39/9 = 4.33 \geq 2$

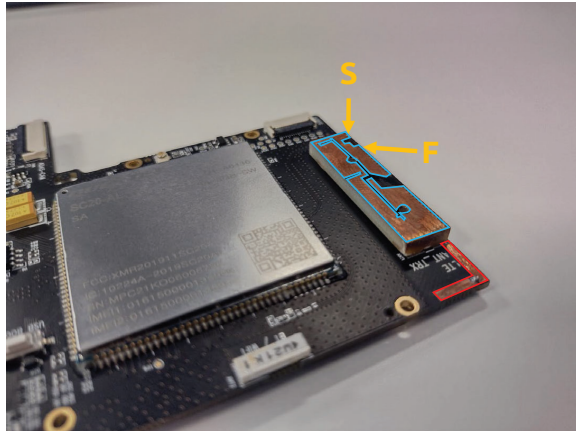


CONFIDENTIAL

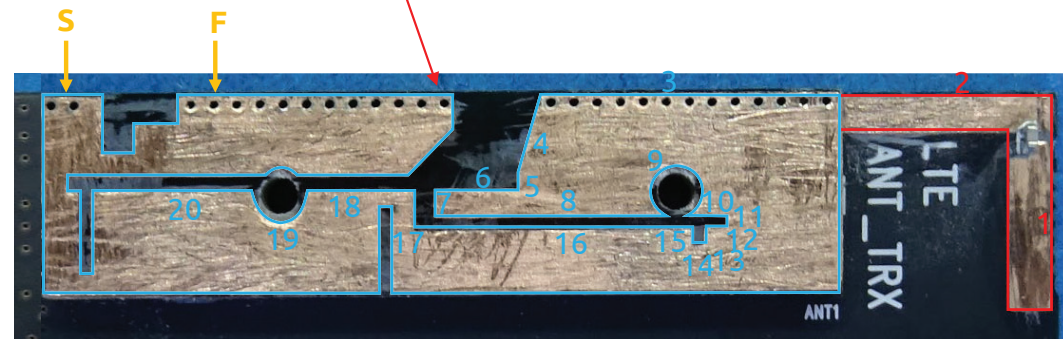
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Claim 13

[13a] The wireless device of claim 12, wherein the first antenna contour comprises at least 20 segments.



[13a] The first antenna contour (indicated in blue and red) comprises at least 20 segments

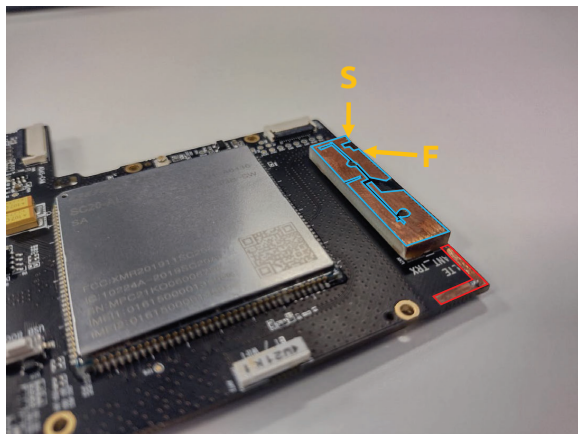


CONFIDENTIAL

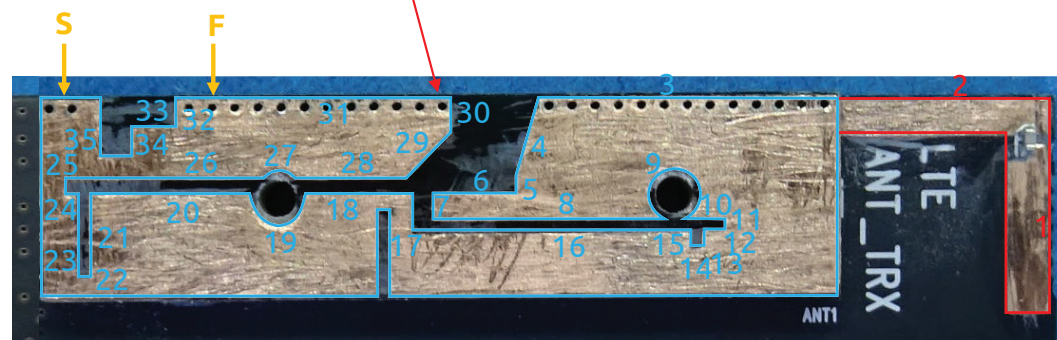
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Claim 14

[14a] The wireless device of claim 13, wherein the first antenna contour comprises at least 35 segments.



[14a] The first antenna contour (indicated in blue and red) comprises at least 35 segments



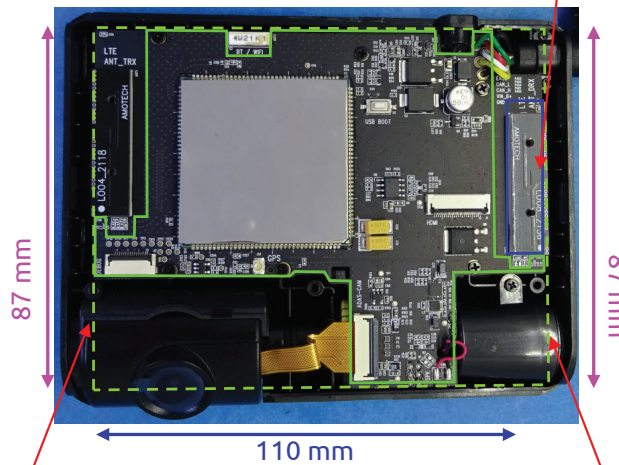
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Claim 15

[15a] The wireless device of claim 12, wherein the second antenna is proximate to a second short side of the ground plane rectangle that is opposite to the first short side of the ground plane rectangle.

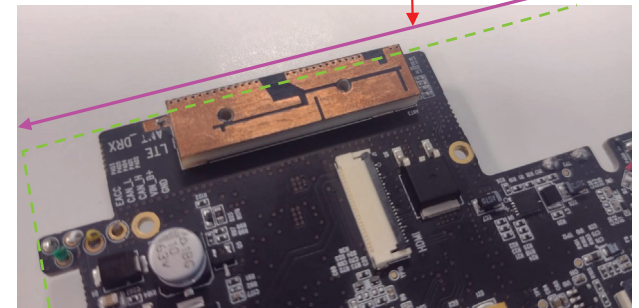
[15a] The second antenna (indicated in blue) being proximate to a second short side of the ground plane rectangle that is opposite to the first short side of the ground plane rectangle



First short side (indicated in pink)

Second short side (indicated in pink)

Second short side (indicated in pink)



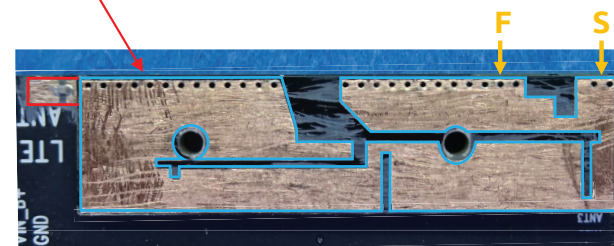
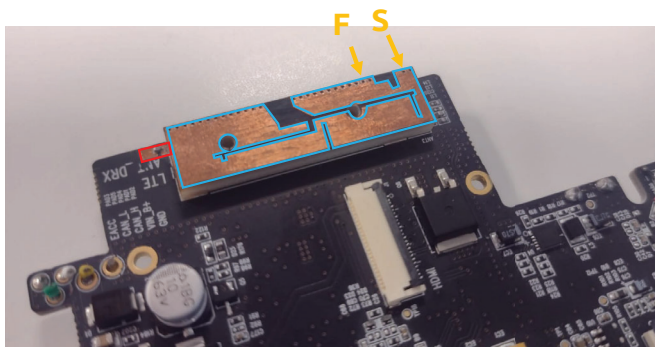
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Claim 16

[16a] The wireless device of claim 12, wherein the second antenna defines a second antenna contour comprising an entire perimeter of the second antenna,

[16a] The second antenna defines a second antenna contour (indicated in blue and red) comprising an entire perimeter of the second antenna



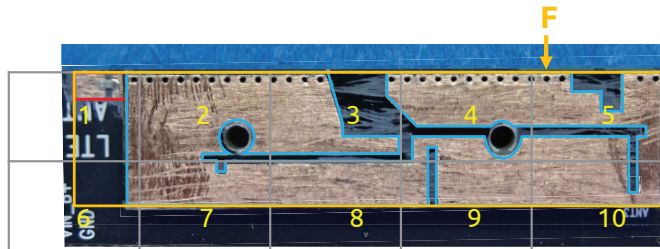
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Claim 16

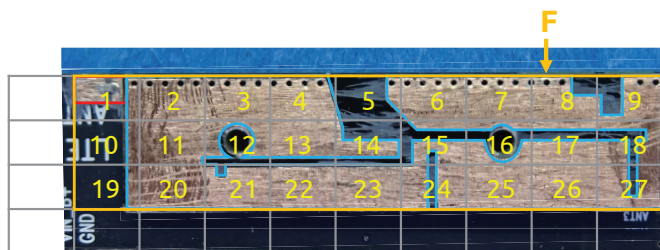
[16b] and wherein the second antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.2 and

[16b] The second antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20



$N_1 = 10 \text{ cells}$

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(27/10)}{\log(2)} = 1.43 \geq 1.20$$



$N_2 = 27 \text{ cells}$

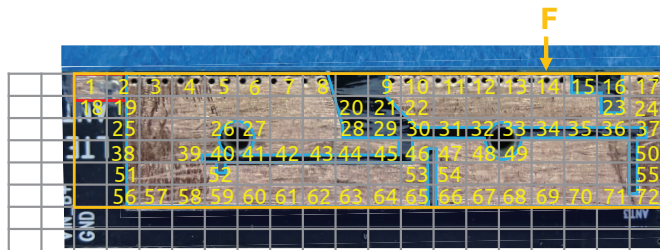
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Claim 16

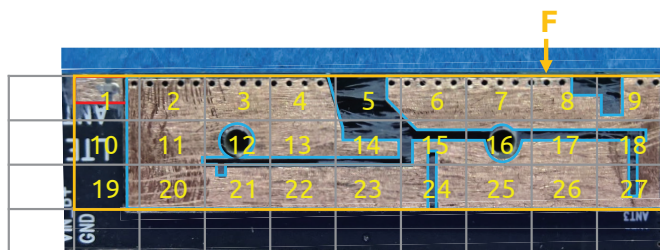
[16c] a complexity factor F_{32} having a value of at least 1.35.

[16c] The second antenna contour has a level of complexity defined by complexity factor F_{32} having a value of at least 1.35



$N_3 = 72 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(72/27)}{\log(2)} = 1.42 \geq 1.35$$



$N_2 = 27 \text{ cells}$

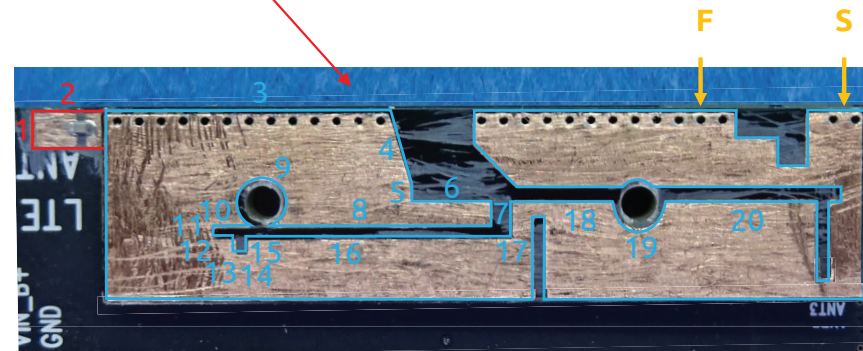
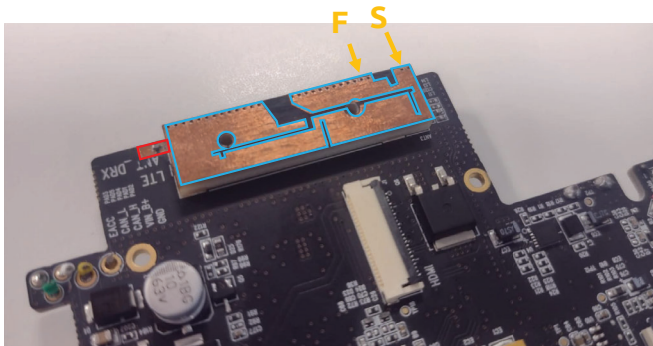
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Claim 17

[17a] The wireless device of claim 16, wherein the second antenna contour comprises at least 20 segments.

[17a] The second antenna contour (indicated in blue and red) comprises at least 20 segments



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Infringement where the diversity antenna is considered the first antenna

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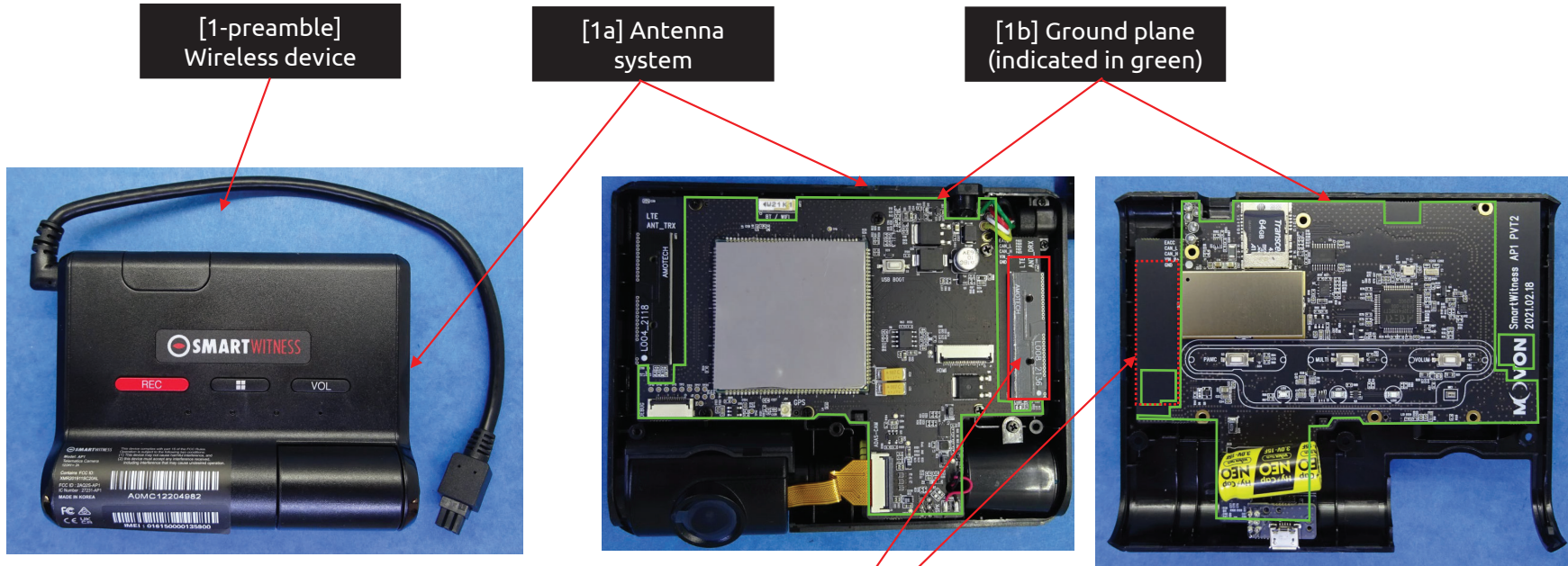
49

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Claim 1

[1-preamble] A wireless device comprising:
[1a] an antenna system comprising:
[1b] a ground plane;
[1c] a first antenna within the wireless device and



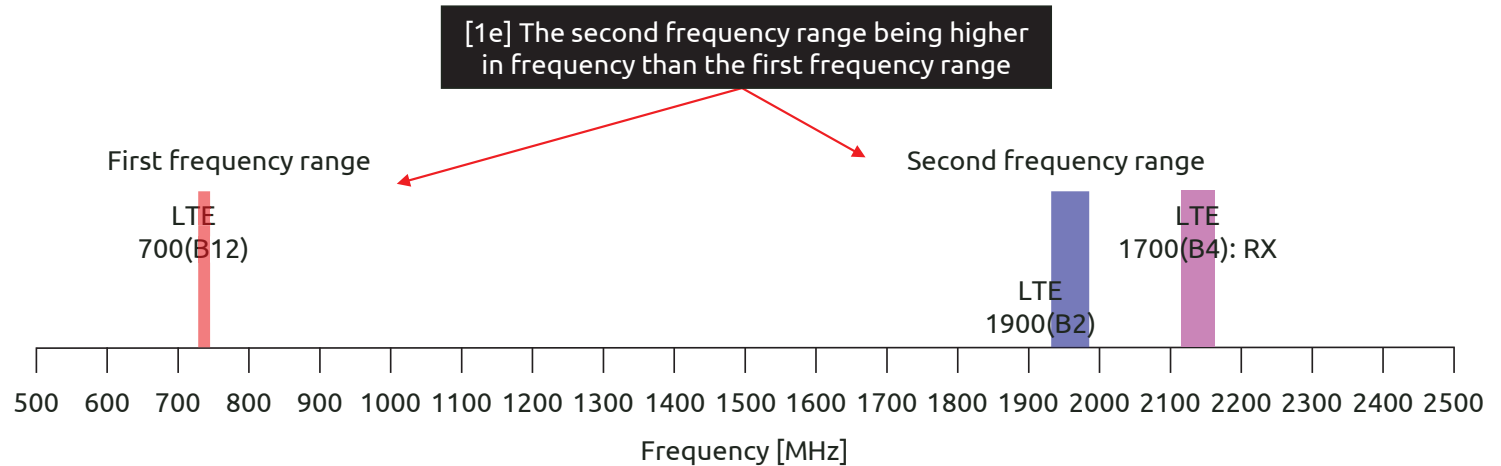
The antenna system comprises a ground plane and [1c] a first antenna (indicated in red) within the wireless device

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Claim 1

[1d] configured to support at least three frequency bands contained within first and second frequency ranges of the electromagnetic spectrum, [1e] the second frequency range being higher in frequency than the first frequency range and [1f] at least one of the three frequency bands being associated with a 4G communication standard,



[1d] At least three frequency bands are contained within first (filled in red) and second frequency ranges (filled in blue) of the electromagnetic spectrum

[1f] At least one of the three frequency bands being associated with a 4G communication standard

Communications	
Antenna	LTE Main, LTE DRX, GNSS, Wi-Fi/BT
US	LTE CAT4: B2, B4, B5, B7, B12, B13, B25, B26 3G Bands: B1, B2, B5, B8
Wireless	EMEA: LTE CAT4: B1, B2, B3, B5, B7, B8, B20, B28A 3G Bands: B1, B2, B5, B8
	Wi-Fi: IEEE 802.11a/b/g/n
	Bluetooth: BT4.2 (BR/EDR+BLE)

Source: device datasheet

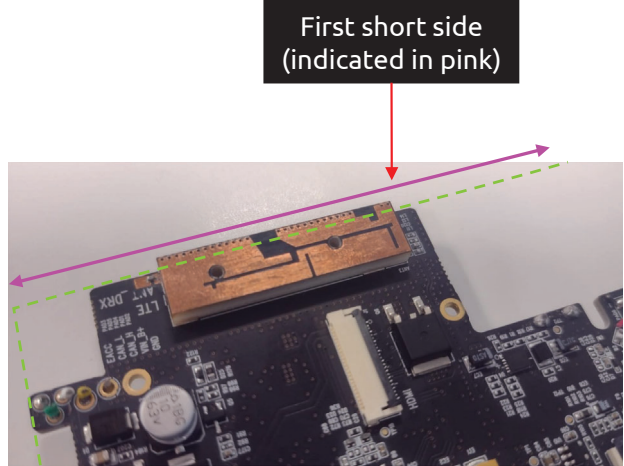
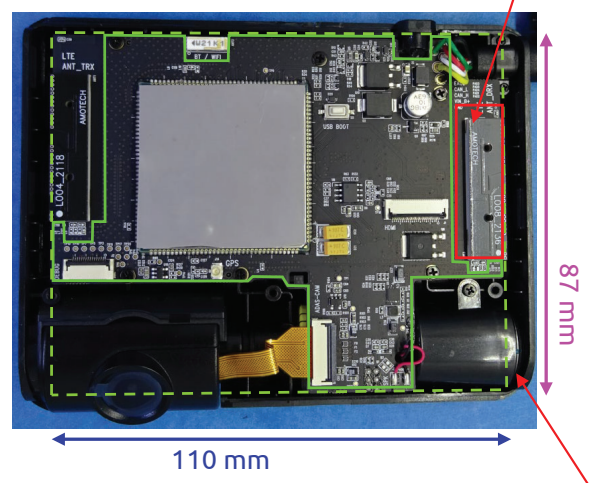
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Claim 1

[1g] the first antenna being proximate to a first short side of a ground plane rectangle enclosing the ground plane and

[1g] The first antenna (indicated in red) is proximate to a first short side of a ground plane rectangle (indicated with a dashed green line) enclosing the ground plane

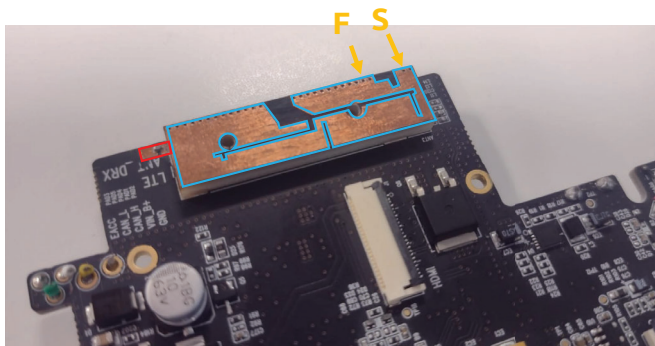


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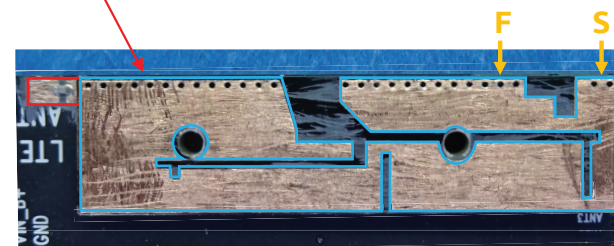
US 11,031,677 - SmartWitness AP1

Claim 1

[1h] defining a first antenna contour comprising an entire perimeter of the first antenna,



[1h] The first antenna defines a first antenna contour (indicated in blue and red) comprising an entire perimeter of the first antenna



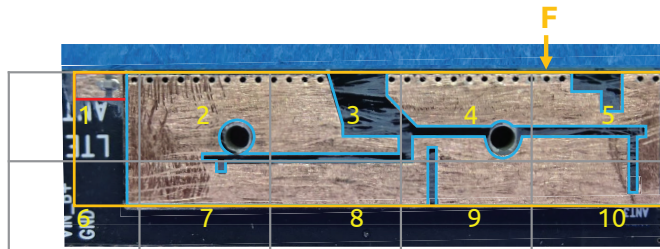
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Claim 1

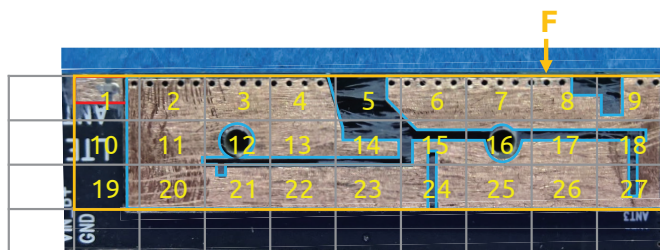
[1i] wherein the first antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and

[1i] The first antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20



$N_1 = 10 \text{ cells}$

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(27/10)}{\log(2)} = 1.43 \geq 1.20$$



$N_2 = 27 \text{ cells}$

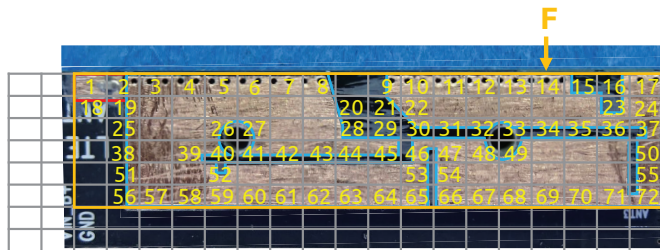
CONFIDENTIAL

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Claim 1

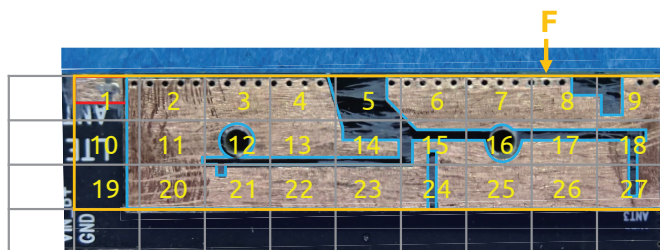
[1j] complexity factor F_{32} having a value less than 1.75; and

[1j] The first antenna contour has a level of complexity defined by complexity factor F_{32} having a value less than 1.75



$N_3 = 72 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(72/27)}{\log(2)} = 1.42 < 1.75$$



$N_2 = 27 \text{ cells}$

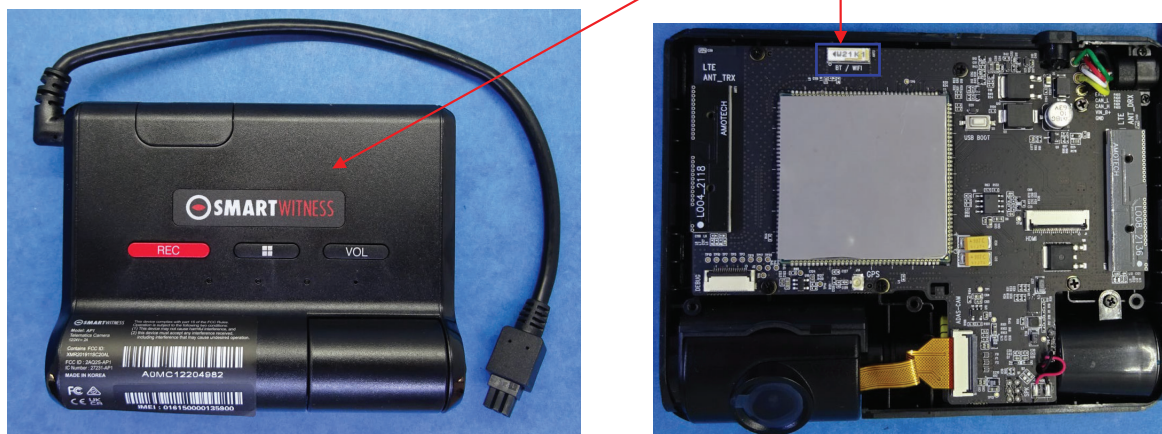
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Claim 1

[1k] a second antenna within the wireless device and

[1k] Second antenna (indicated in blue) within the wireless device



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Claim 1

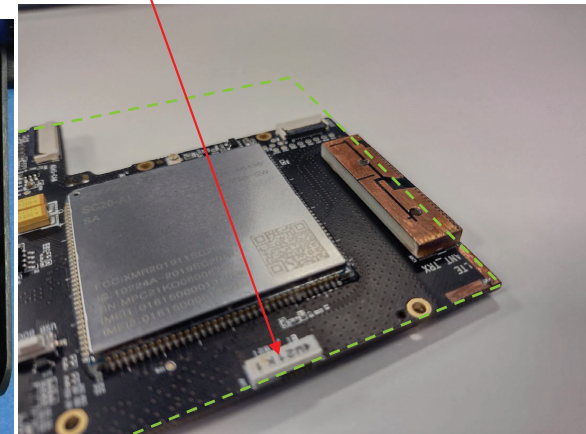
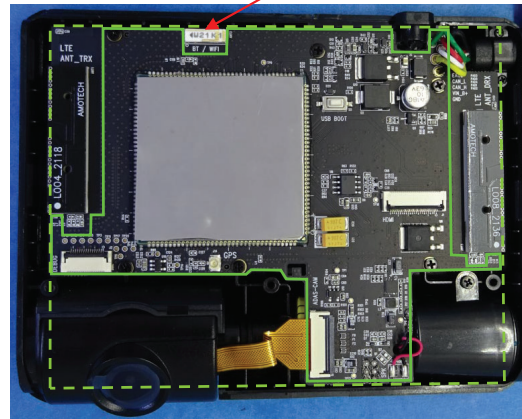
[1l] configured to support at least one frequency band different from the at least three frequency bands supported by the first antenna, [1m] the second antenna being arranged completely within the ground plane rectangle.

[1l] The second antenna is configured to support at least one frequency band (2.4 GHz) different from the at least three frequency bands supported by the first antenna

[1m] The second antenna is arranged completely within the ground plane rectangle

Communications	
Antenna	LTE Main, LTE DRX, GNSS, Wi-Fi/BT
US	LTE CAT4: B2, B4, B5, B7, B12, B13, B25, B26 3G Bands: B1, B2, B5, B8
EMEA	LTE CAT4: B1, B2, B3, B5, B7, B8, B20, B28A 3G Bands: B1, B2, B5, B8
Wireless	Wi-Fi: IEEE 802.11a/b/g/n Bluetooth: BT4.2 (BR/EDR+BLE)

Source: device datasheet

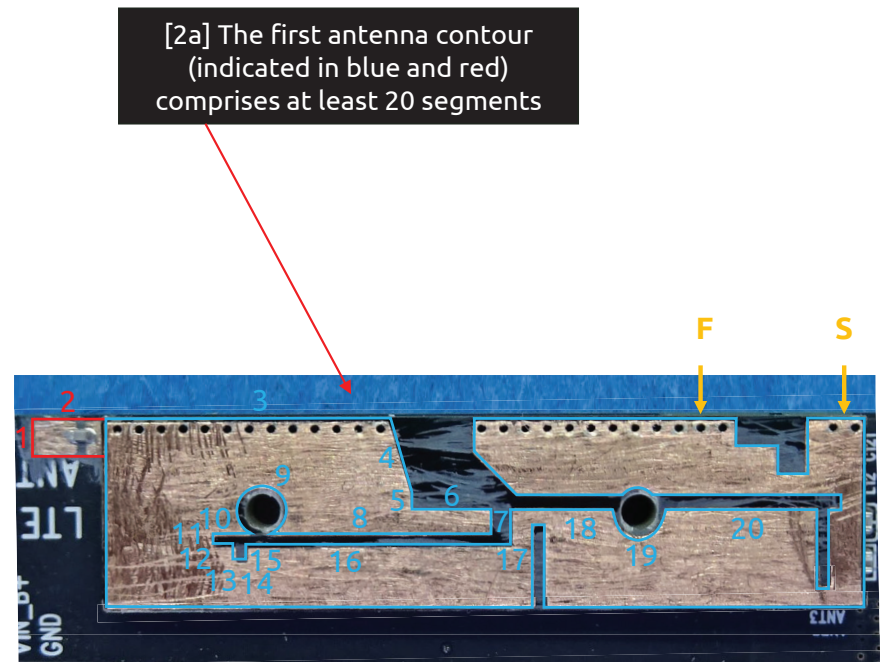
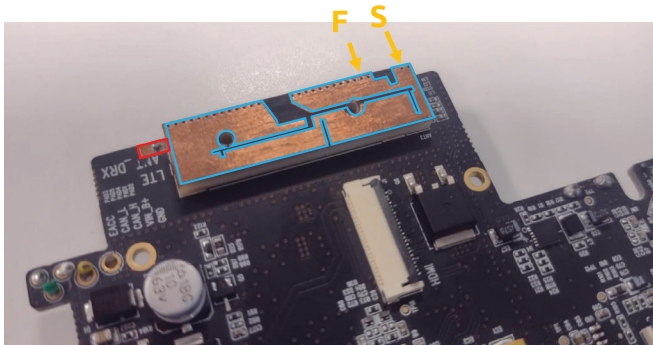


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Claim 2

[2a] The wireless device of claim 1, wherein the first antenna contour comprises at least 20 segments.



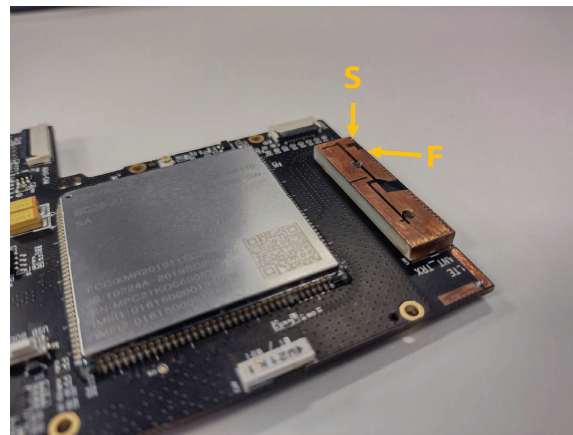
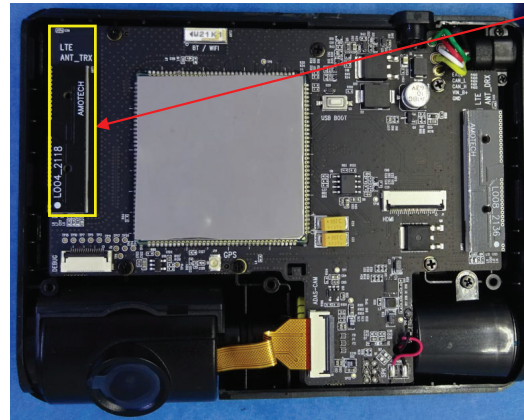
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US 11,031,677 - SmartWitness AP1

Claim 4

[4a] The wireless device of claim 1, wherein the antenna system comprises a third antenna configured to receive signals employing a 4G communication standard.

[4a] The antenna system comprises a third antenna (indicated in yellow) configured to receive signals employing a 4G communication standard



Communications

Antenna	LTE Main, LTE DRX, GNSS, Wi-Fi/BT
US	LTE CAT4: B2, B4, B5, B7, B12, B13, B25, B26 3G Bands: B1, B2, B5, B8
Wireless	EMEA LTE CAT4: B1, B2, B3, B5, B7, B8, B20, B28A 3G Bands: B1, B2, B5, B8
	Wi-Fi: IEEE 802.11a/b/g/n
	Bluetooth: BT4.2 (BR/EDR+BLE)

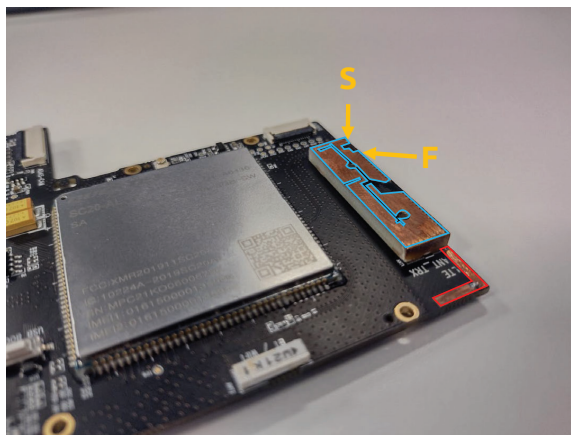
Source: device datasheet

CONFIDENTIAL

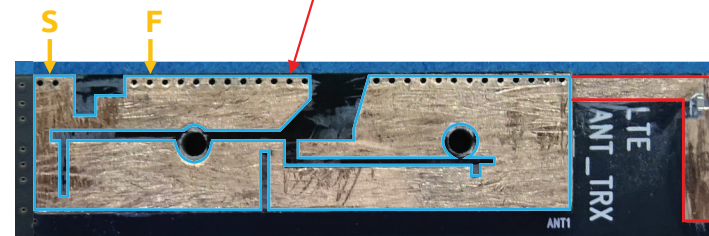
US 11,031,677 - SmartWitness AP1

Claim 5

[5a] The wireless device of claim 4, wherein the third antenna defines an antenna contour comprising an entire perimeter of the third antenna, and



[5a] The third antenna defines an antenna contour (indicated in blue and red) comprising an entire perimeter of the third antenna



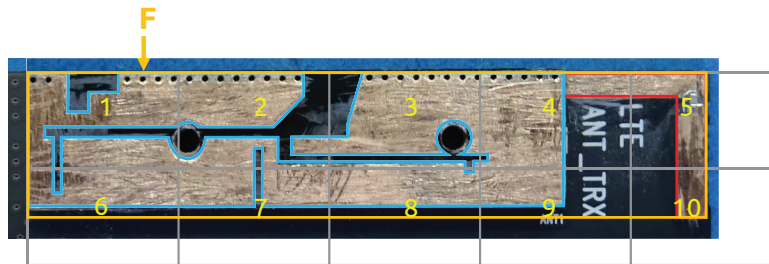
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Claim 5

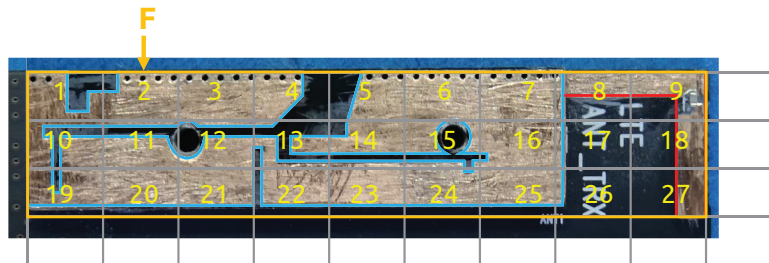
[5b] wherein the antenna contour of the third antenna has a level of complexity defined by complexity factor F_{21} having a value of at least 1.2 and

[5b] The antenna contour of the third antenna has a level of complexity defined by complexity factor F_{21} having a value of at least 1.2



$N_1 = 10$ cells

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(27/10)}{\log(2)} = 1.43 \geq 1.20$$



$N_2 = 27$ cells

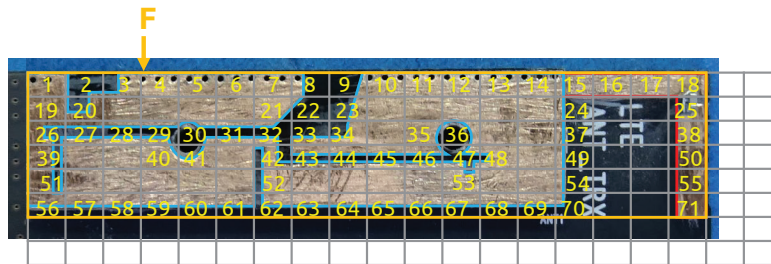
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Claim 5

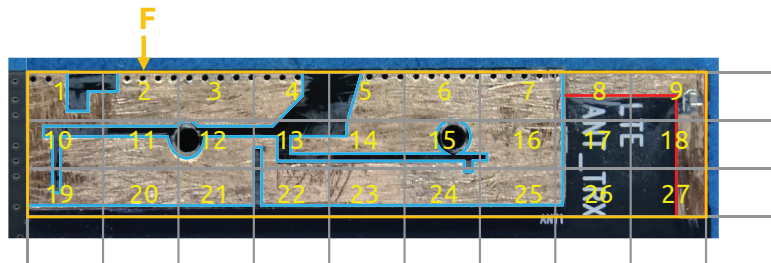
[5c] a complexity factor F_{32} having a value of at least 1.35.

[5c] The antenna contour of the third antenna has a level of complexity defined by complexity factor F_{32} having a value of at least 1.35



$N_3 = 71 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(71/27)}{\log(2)} = 1.39 \geq 1.35$$



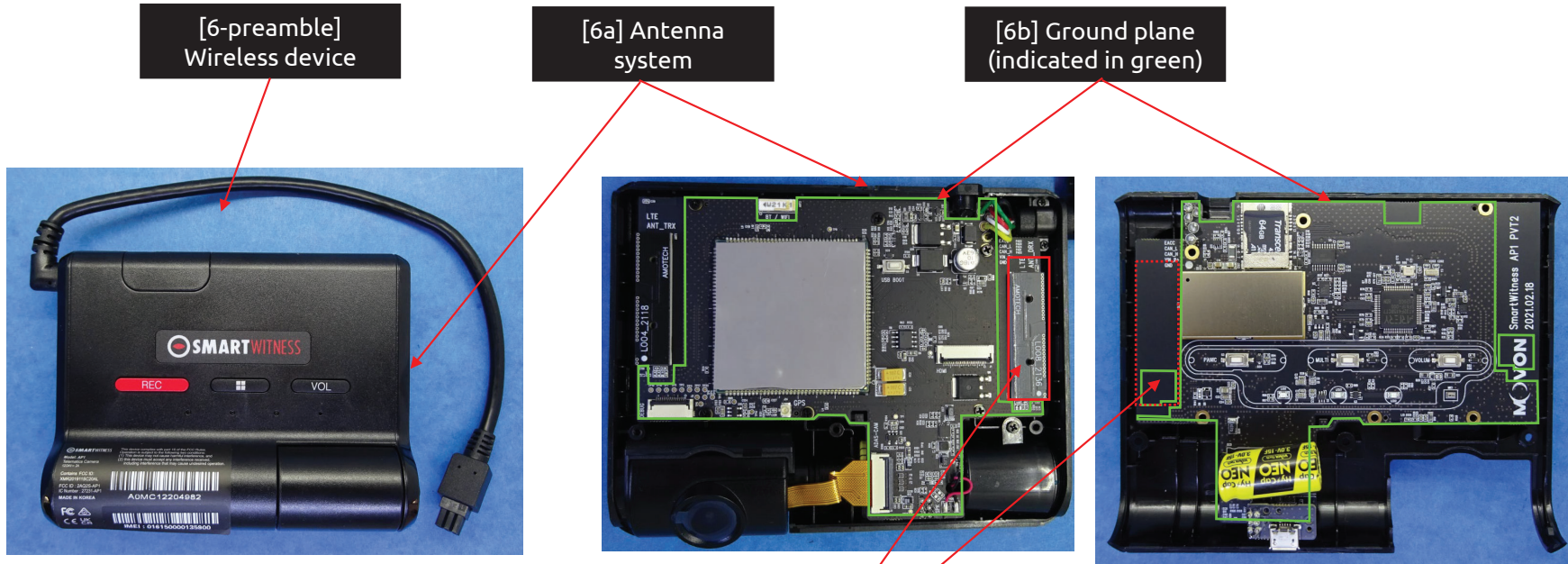
$N_2 = 27 \text{ cells}$

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Claim 6

[6-preamble] A wireless device comprising:
[6a] an antenna system comprising:
[6b] a ground plane;
[6c] a first antenna within the wireless device and



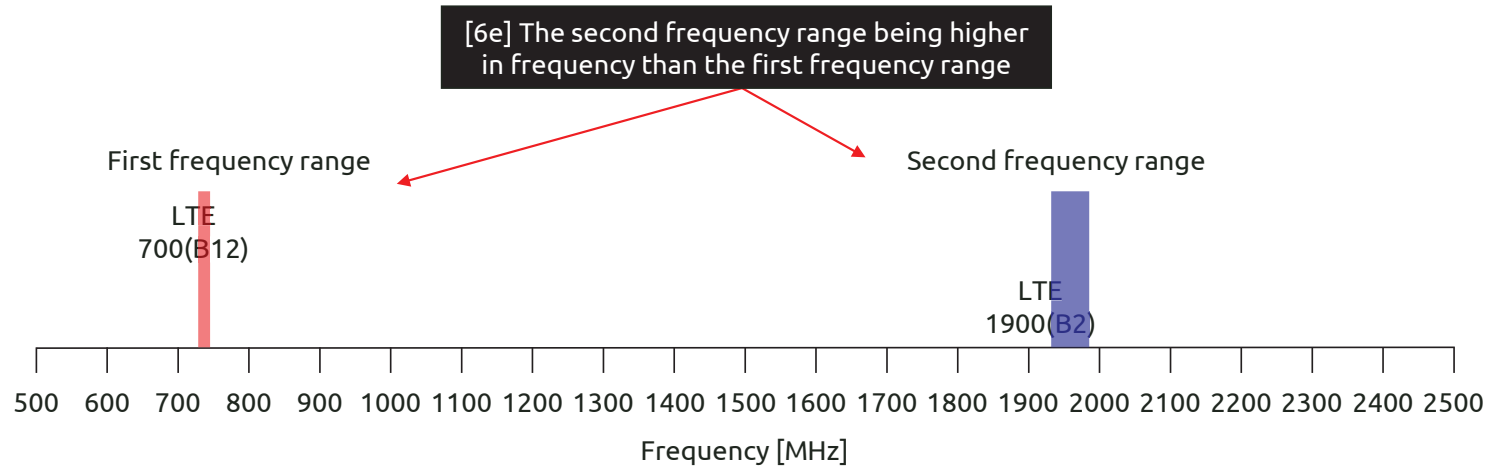
The antenna system comprises a ground plane and [6c] a first antenna (indicated in red) within the wireless device

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US 11,031,677 - SmartWitness AP1

Claim 6

[6d] configured to support at least two frequency bands contained within first and second frequency ranges of the electromagnetic spectrum, [6e] the second frequency range being higher in frequency than the first frequency range,



[6d] At least two frequency bands are contained within first (filled in red) and second frequency ranges (filled in blue) of the electromagnetic spectrum

Communications	
Antenna	LTE Main, LTE DTX, GNSS, Wi-Fi, BT
US	LTE CAT4: B2, B4, B5, B7, B12, B13, B25, B26
	3G Bands: B1, B2, B5, B8
EMEA	LTE CAT4: B1, B2, B3, B5, B7, B8, B20, B28A
	3G Bands: B1, B2, B5, B8
Wireless	Wi-Fi: IEEE 802.11a/b/g/n
	Bluetooth: BT4.2 (BR/EDR+BLE)

Source: device datasheet

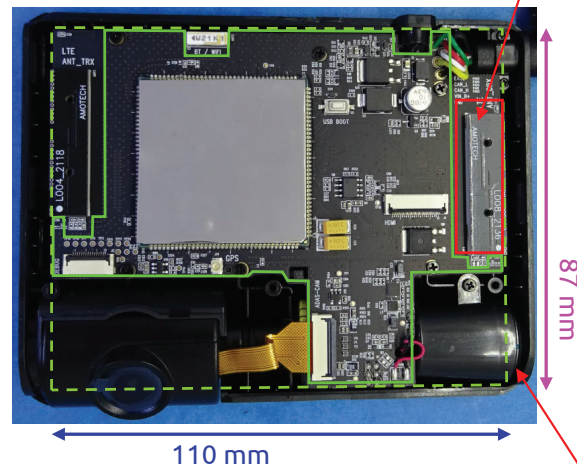
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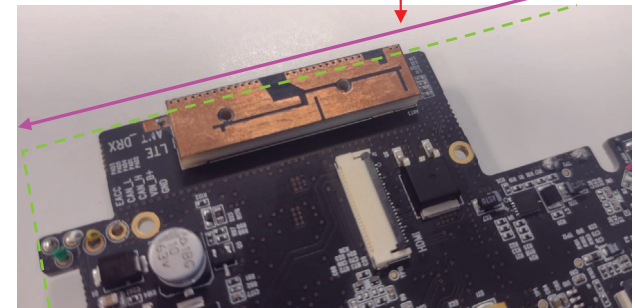
Claim 6

[6f] the first antenna being proximate to a first short side of a ground plane rectangle enclosing the ground plane and

[6f] The first antenna (indicated in red) is proximate to a first short side of a ground plane rectangle (indicated with a dashed green line) enclosing the ground plane



First short side (indicated in pink)



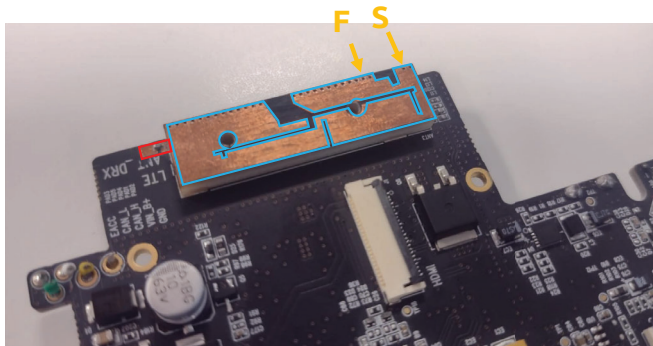
First short side (indicated in pink)

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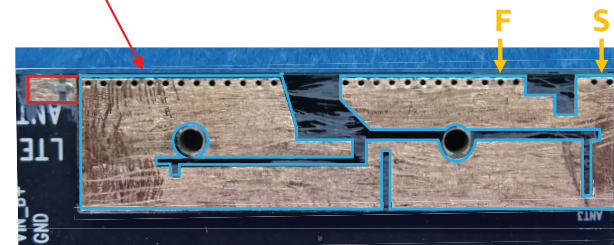
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Claim 6

[6g] defining a first antenna contour comprising an entire perimeter of the first antenna,



[6g] The first antenna defines a first antenna contour (indicated in blue and red) comprising an entire perimeter of the first antenna



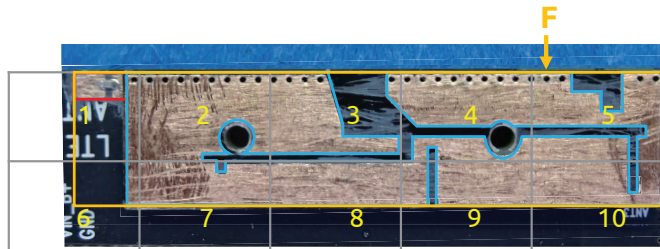
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Claim 6

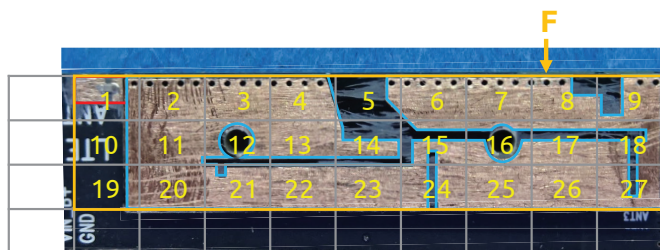
[6h] wherein the first antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and

[6h] The first antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20



$N_1 = 10 \text{ cells}$

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(27/10)}{\log(2)} = 1.43 \geq 1.20$$



$N_2 = 27 \text{ cells}$

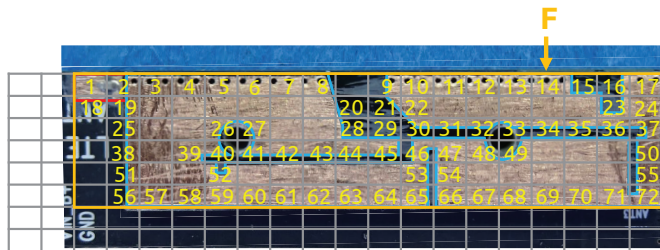
CONFIDENTIAL

US 11,031,677 - SmartWitness AP1

Claim 6

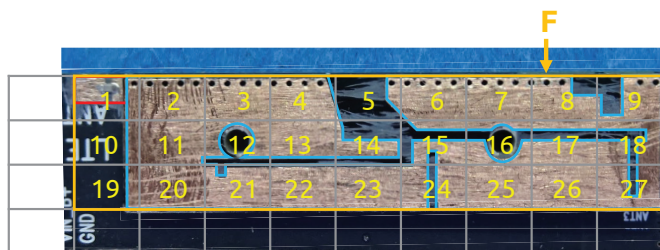
[6i] complexity factor F_{32} having a value less than 1.75; and

[6i] The first antenna contour has a level of complexity defined by complexity factor F_{32} having a value less than 1.75



$N_3 = 72 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(72/27)}{\log(2)} = 1.42 < 1.75$$



$N_2 = 27 \text{ cells}$

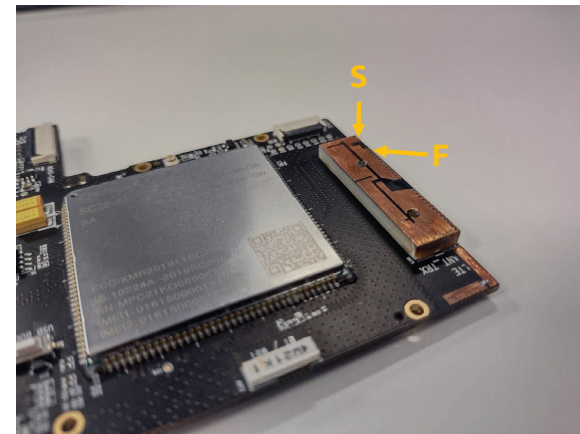
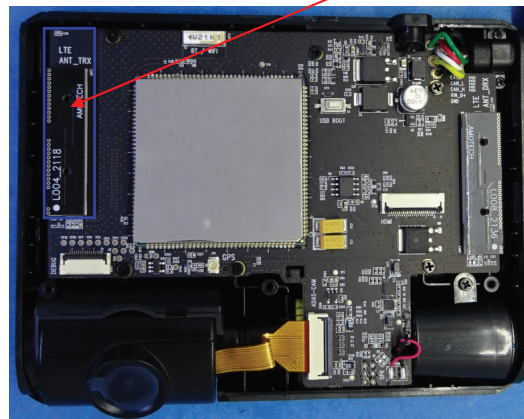
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Claim 6

[6j] a second antenna within the wireless device and

[6j] Second antenna (indicated in blue) within the wireless device

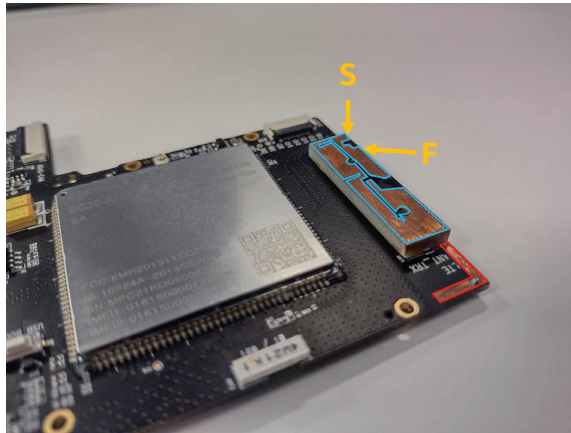


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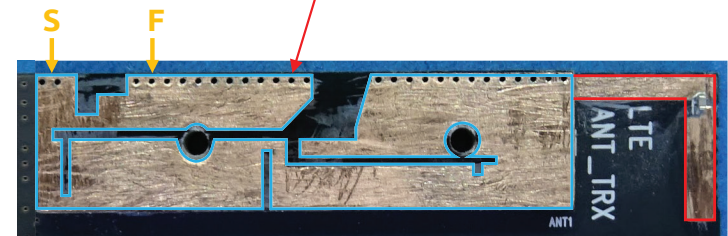
US 11,031,677 - SmartWitness AP1

Claim 6

[6k] defining a second antenna contour comprising an entire perimeter of the second antenna,



[6k] The second antenna defines a second antenna contour (indicated in blue and red) comprising an entire perimeter of the second antenna



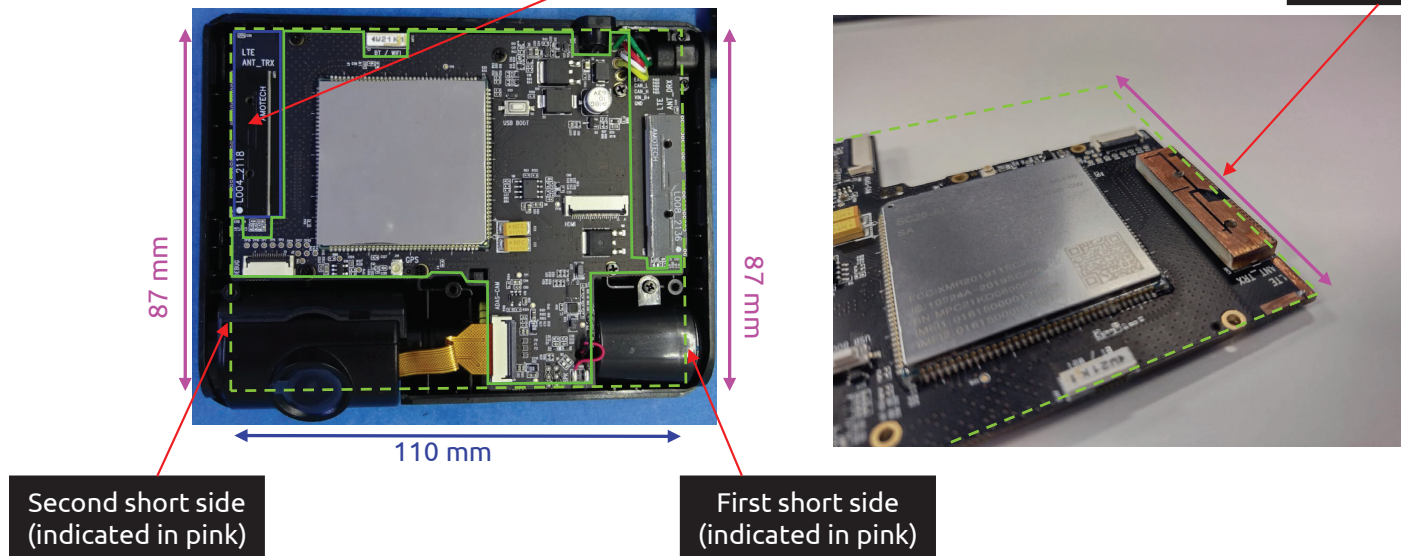
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Claim 6

[6] the second antenna being proximate to a second short side of the ground plane rectangle that is opposite to the first short side of the ground plane rectangle,

[6] The second antenna (indicated in blue) being proximate to a second short side of the ground plane rectangle that is opposite to the first short side of the ground plane rectangle



Second short side (indicated in pink)

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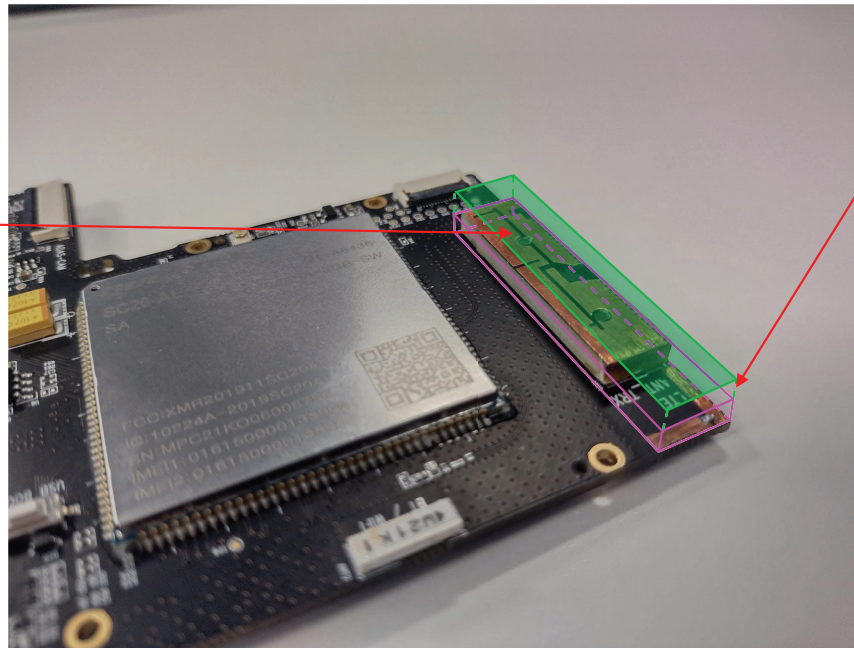
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Claim 6

[6n] an orthogonal projection of the antenna box along a normal to a face with a largest area of the second antenna defining
[6o] an antenna rectangle,

[6n] An orthogonal projection of the antenna box along a normal to a face* with a largest area of the second antenna

[6o] Antenna rectangle (filled in green)



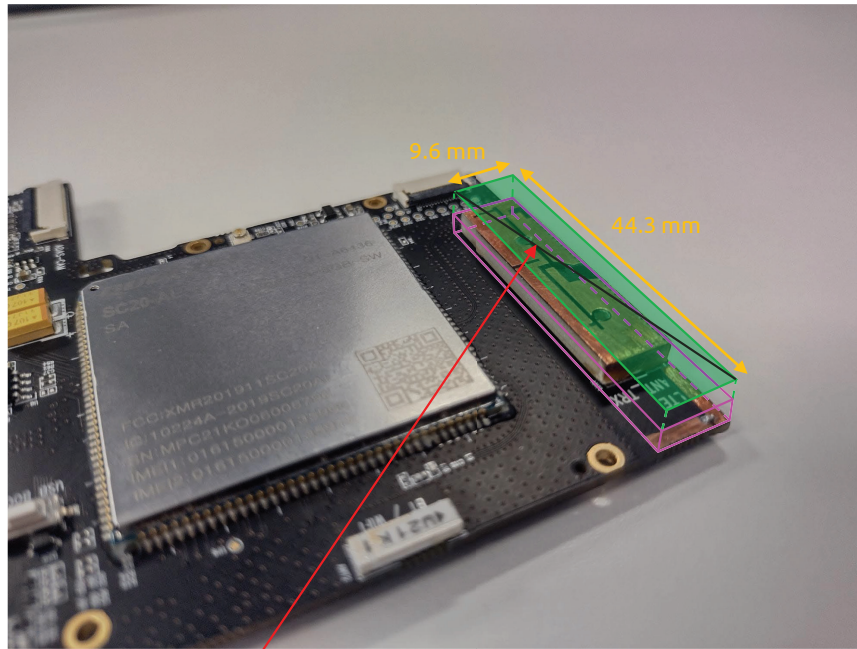
*Normal to a face means perpendicular to the face

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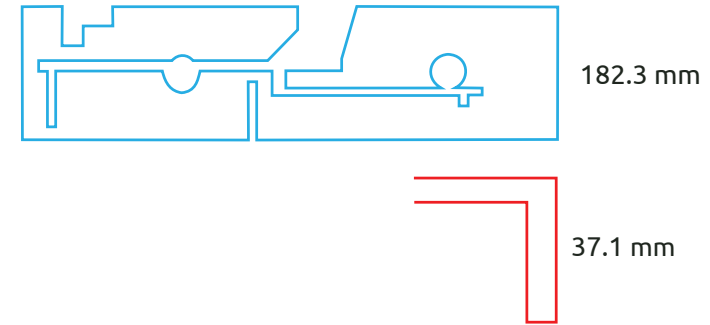
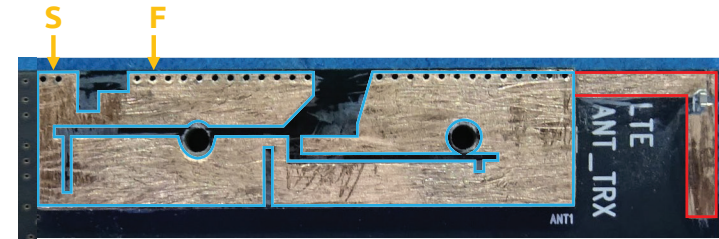
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Claim 6

[6p] wherein a length of the second antenna contour is greater than four times a diagonal of the antenna rectangle.



Diagonal of the antenna rectangle = 45.33 mm



Length of the second antenna contour = $(182.3 + 37.1) = 219.4$ mm

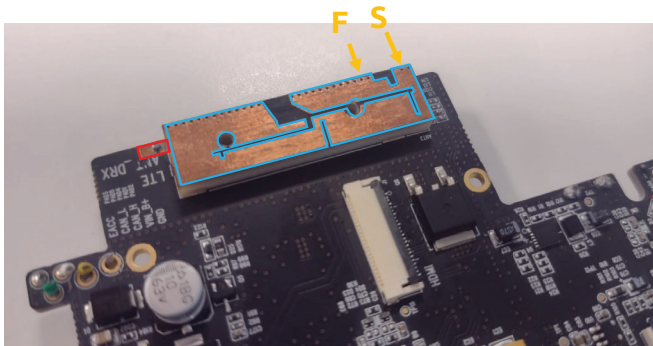
[6p] The length of the second antenna contour (219.4 mm) > 4*Diagonal of the antenna rectangle ($4*45.33 = 181.32$ mm)

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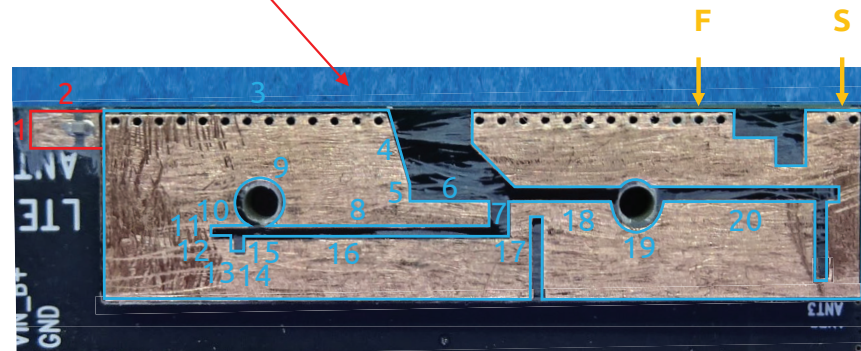
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Claim 7

[7a] The wireless device of claim 6, wherein the first antenna contour comprises at least 20 segments.



[7a] The first antenna contour (indicated in blue and red) comprises at least 20 segments

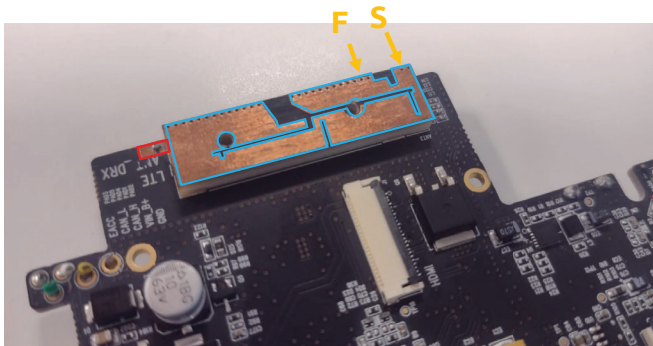


CONFIDENTIAL

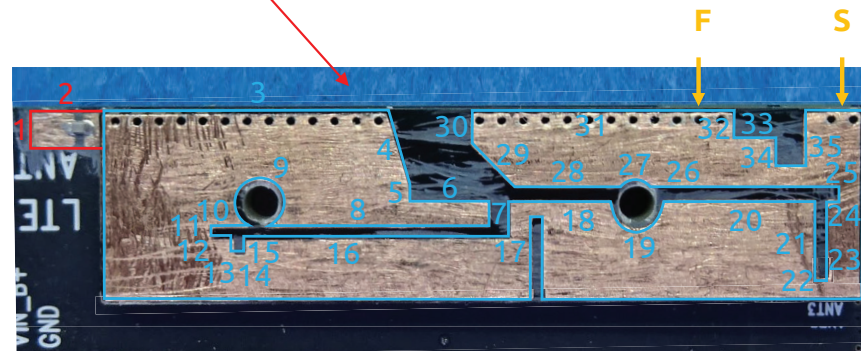
US 11,031,677 - SmartWitness AP1

Claim 8

[8a] The wireless device of claim 7, wherein the first antenna contour comprises at least 35 segments.



[8a] The first antenna contour (indicated in blue and red) comprises at least 35 segments



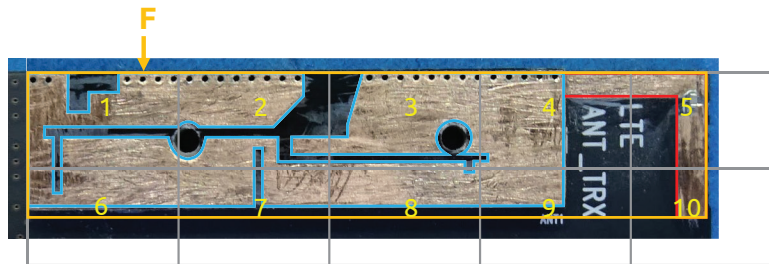
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Claim 9

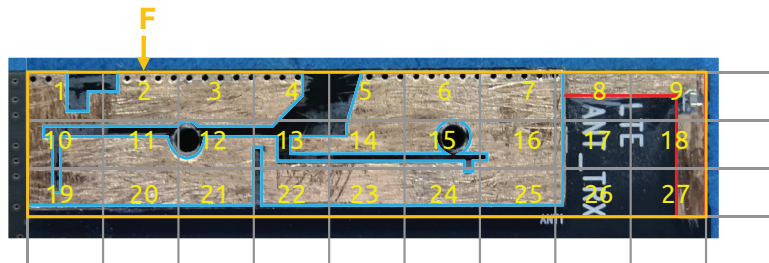
[9a] The wireless device of claim 6, wherein the second antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.2 and

[9a] The second antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20



$N_1 = 10 \text{ cells}$

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(27/10)}{\log(2)} = 1.43 \geq 1.20$$



$N_2 = 27 \text{ cells}$

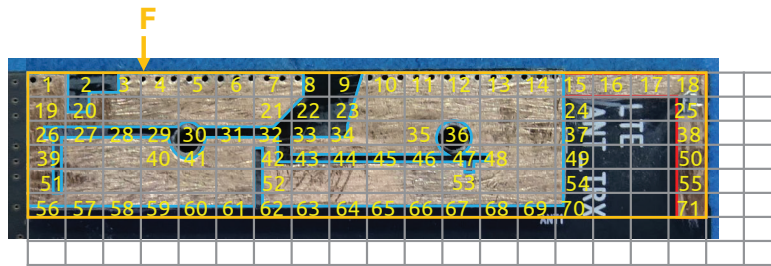
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Claim 9

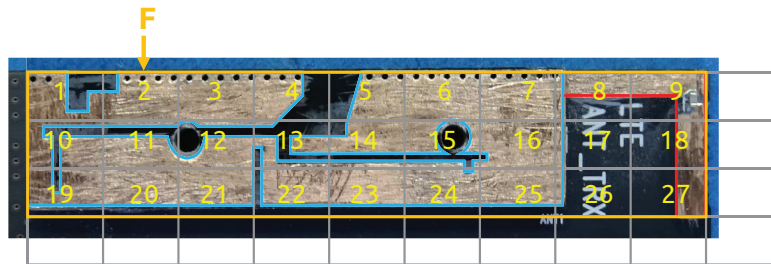
[9b] a complexity factor F_{32} having a value of at least 1.35.

[9b] The second antenna contour has a level of complexity defined by complexity factor F_{32} having a value of at least 1.35



$N_3 = 71 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(71/27)}{\log(2)} = 1.39 \geq 1.35$$



$N_2 = 27 \text{ cells}$

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