

SmartWitness CP2

Infringement where the main antenna is
considered the first antenna

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1

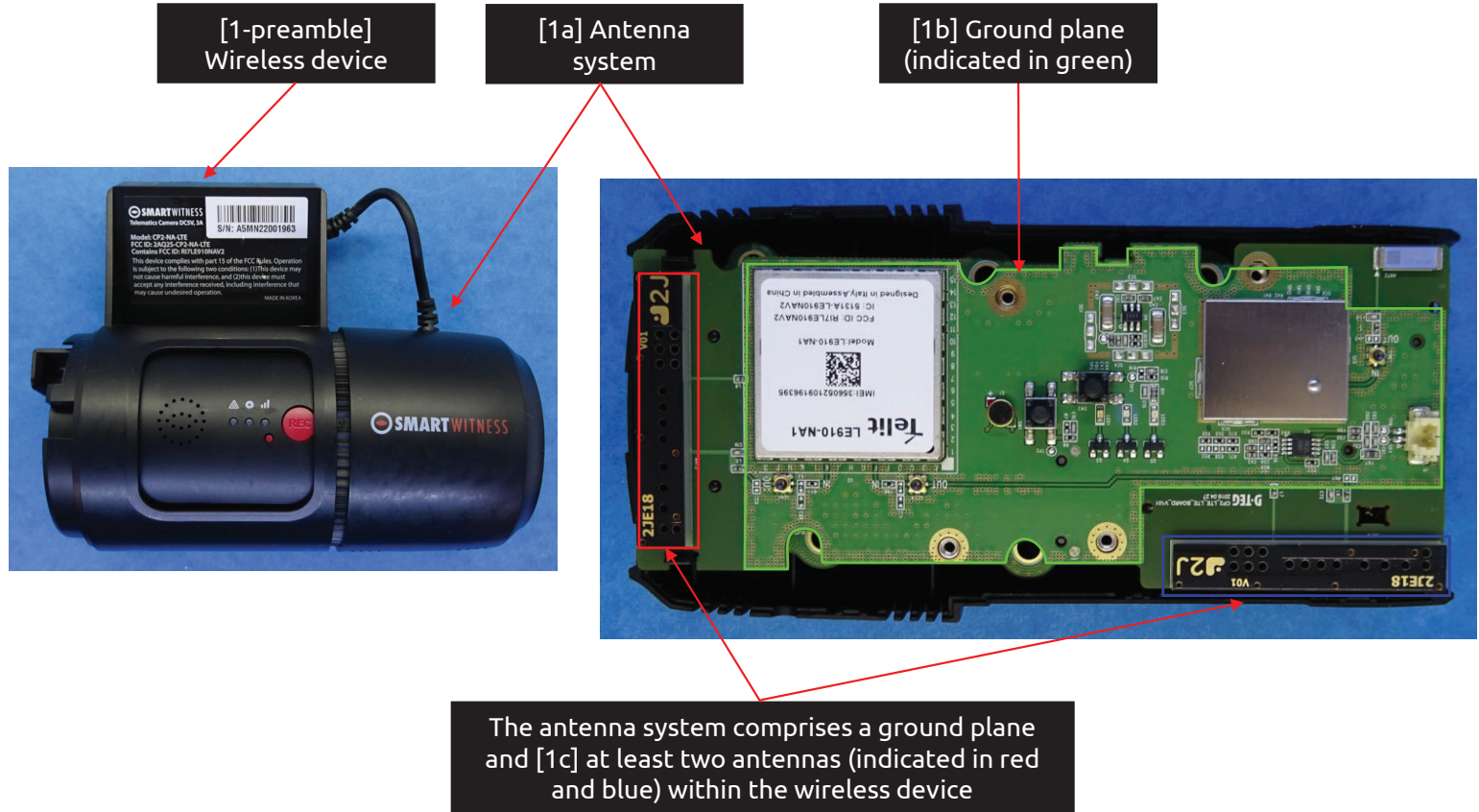
Geotab Exhibit 1057
Geotab v. Fractus

~~CONFIDENTIAL - PROTECTIVE ORDER MATERIAL~~

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Claim 1

[1-preamble] A wireless device comprising [1a] an antenna system comprising [1b] a ground plane and [1c] at least two antennas within the wireless device, the antenna system comprising:



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Claim 1

[1d] a first antenna proximate to a first short side of a ground plane rectangle enclosing the ground plane,

[1d] 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



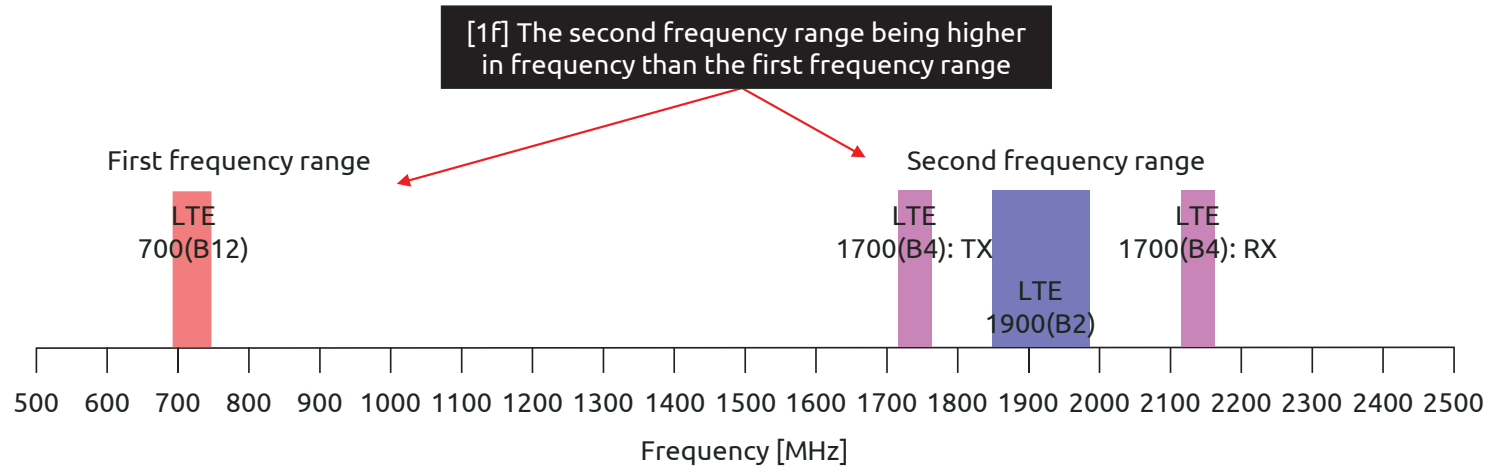
First short side (indicated in pink)

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Claim 1

[1e] the first antenna being configured to support at least three frequency bands contained within first and second frequency ranges of the electromagnetic spectrum
 [1f] the second frequency range being higher in frequency than the first frequency range
 [1g] the first antenna being configured to transmit and receive signals from a 4G communication standard,



[1e] First antenna being configured to support at least three frequency bands contained within first (filled in red) and second frequency ranges (filled in blue) of the electromagnetic spectrum

[1g] First antenna being configured to transmit and receive signals from a 4G communication standard

Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700), B13 (700C); [3G] B2 (1900), B5 (850)
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: user manual

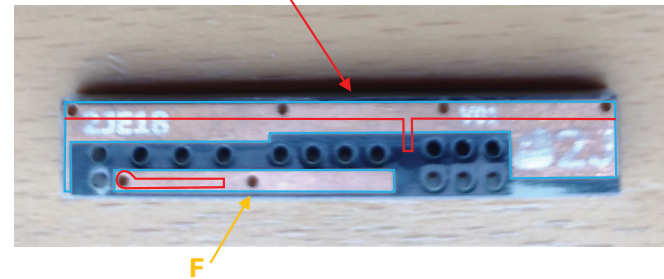
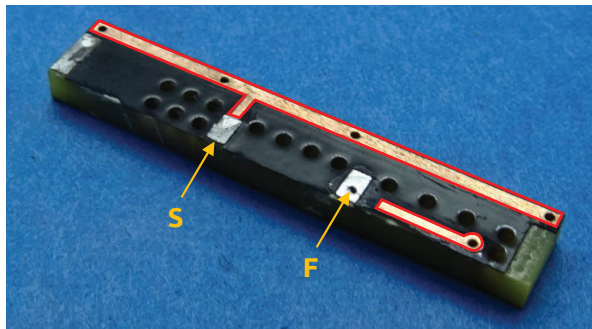
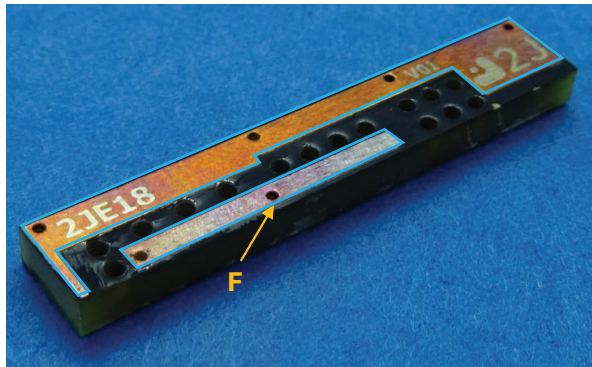
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Claim 1

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

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



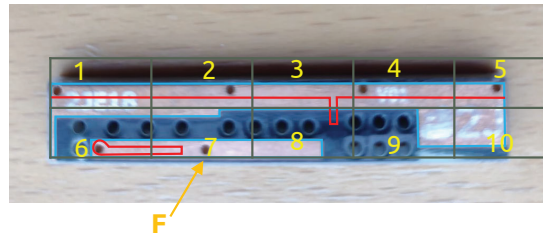
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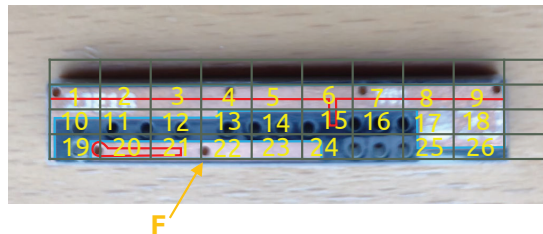
Claim 1

[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



$N_1 = 10 \text{ cells}$



$N_2 = 26 \text{ cells}$

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(26/10)}{\log(2)} = 1.38 \geq 1.20$$

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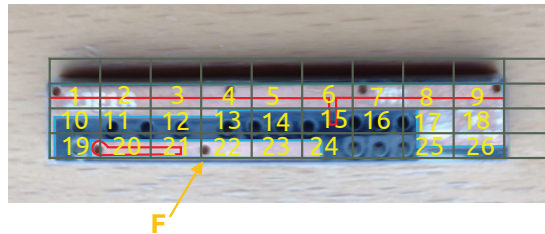
Claim 1

[1j] complexity factor F_{32} having a value of at least 1.35; and

[1j] The first antenna contour has a level of complexity defined by complexity factor F_{32} having a value of at least 1.35



$N_3 = 84 \text{ cells}$



$N_2 = 26 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(84/26)}{\log(2)} = 1.69 \geq 1.35$$

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Claim 1

[1k] a second antenna proximate to a first long side of the ground plane rectangle, and

[1k] Second antenna (indicated in blue) proximate to a first long side of the ground plane rectangle



First long side (indicated in blue)

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Claim 1

[1] wherein the second antenna is configured to receive signals from a 4G communication standard.

[1] Second antenna (indicated in blue) is configured to receive signals employing a 4G communication standard



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: User Manual

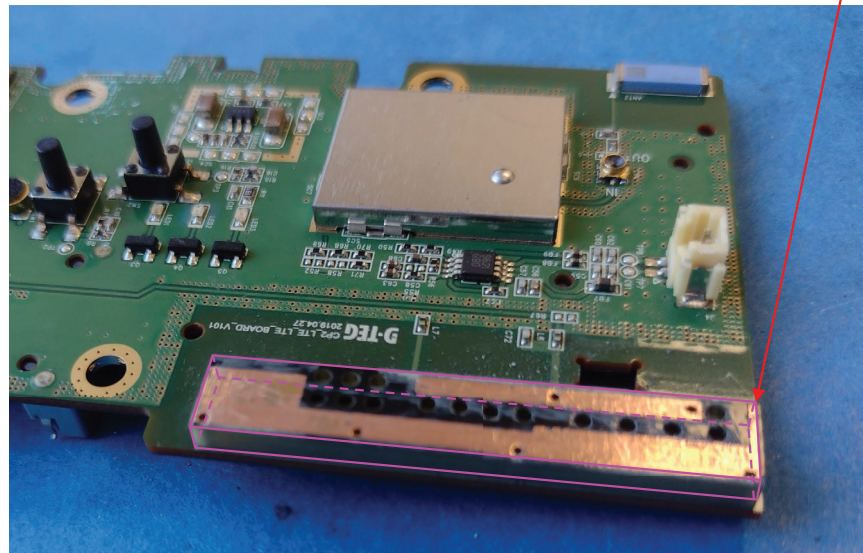
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Claim 2

[2a] The wireless device of claim 1, wherein the second antenna defines an antenna box that is a minimum-sized parallelepiped that completely encloses a volume of the second antenna and wherein each face of the minimum-sized parallelepiped is tangent to at least one point of the volume of the second antenna,

[2a] The second antenna defines a defines an antenna box (outlined in pink) that is a minimum-sized parallelepiped that completely encloses a volume of the second antenna and wherein each face of the minimum-sized parallelepiped is tangent to at least one point of the volume of the second antenna,



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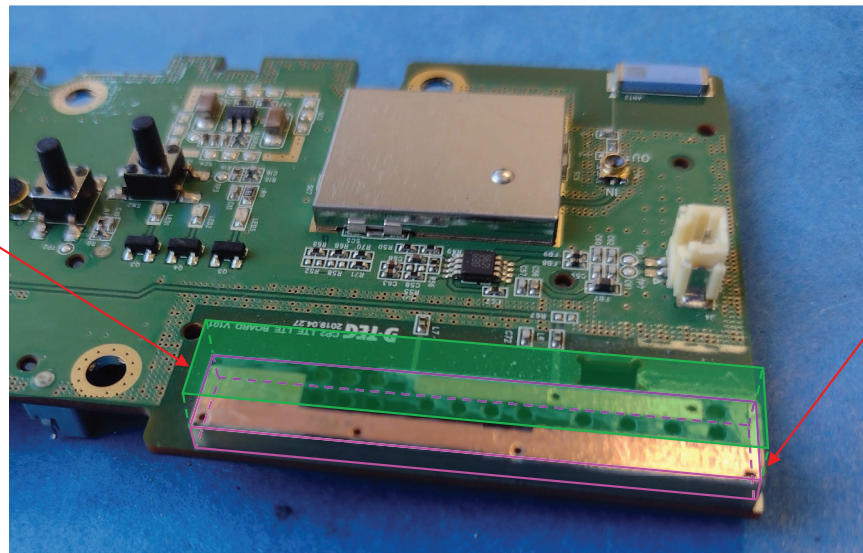
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Claim 2

[2b] an orthogonal projection of the antenna box along a normal to a face with a largest area of the second antenna defining
[2c] an antenna rectangle,

[2c] Antenna rectangle
(filled in green)

[2b] 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

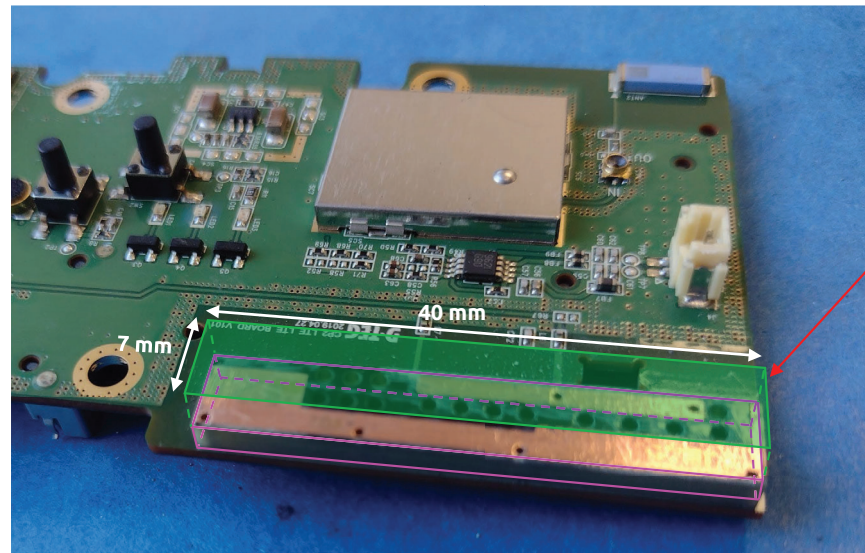
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Claim 2

[2d] 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.

[2d] 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 $40/7 = 5.71 \geq 2$

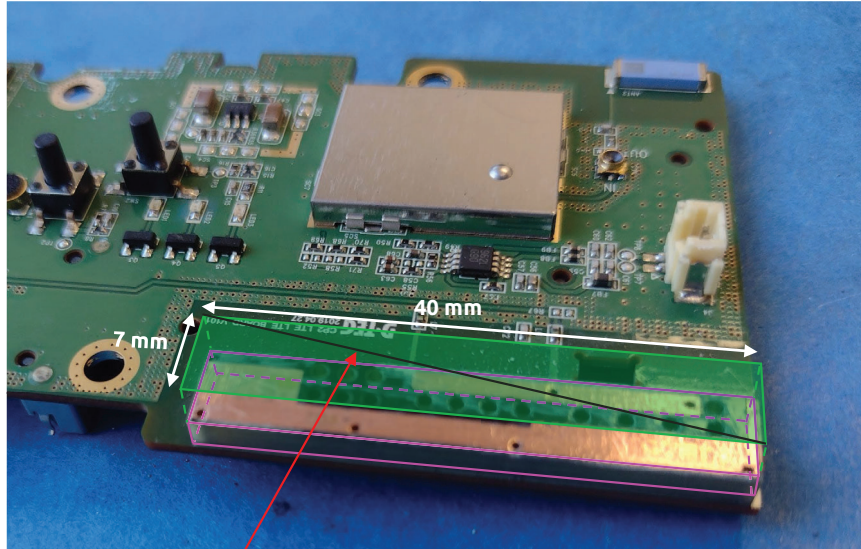


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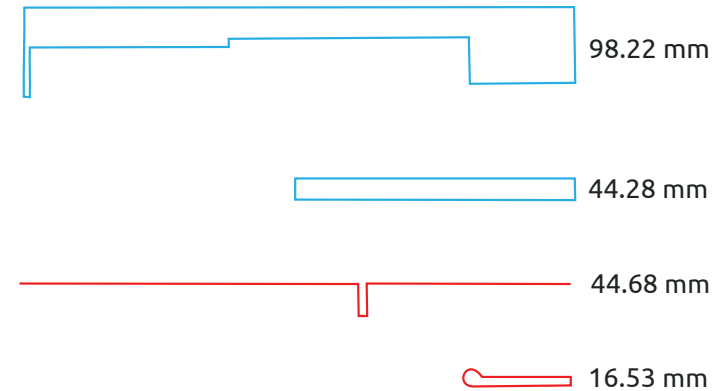
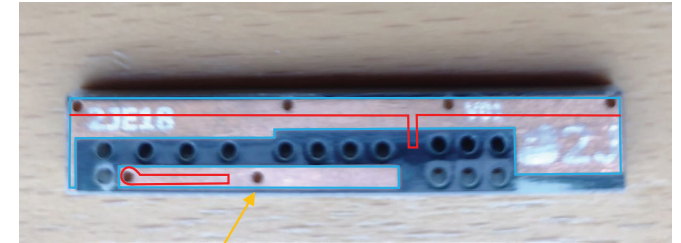
Claim 3

[3a] The wireless device of claim 2, wherein the second antenna defines a second antenna contour comprising an entire perimeter of the second antenna, wherein a length of the second antenna contour is greater than four times a diagonal of the antenna rectangle.



Diagonal of the antenna rectangle = 40.61 mm

[3a] The length of the second antenna contour (203.71 mm) > 4*Diagonal of the antenna rectangle (4*40.61 = 162.43 mm)



Length of the second antenna contour = (98.22 + 44.28 + 44.68 + 16.53) = 203.71 mm

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Claim 4

[4a] The wireless device of claim 1, wherein the first antenna is configured to support at least four frequency bands.

[4a] The first antenna (indicated in red) is configured to support at least LTE 700(B12)/850(B5)/1700-2100(B4)/1900(B2)



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

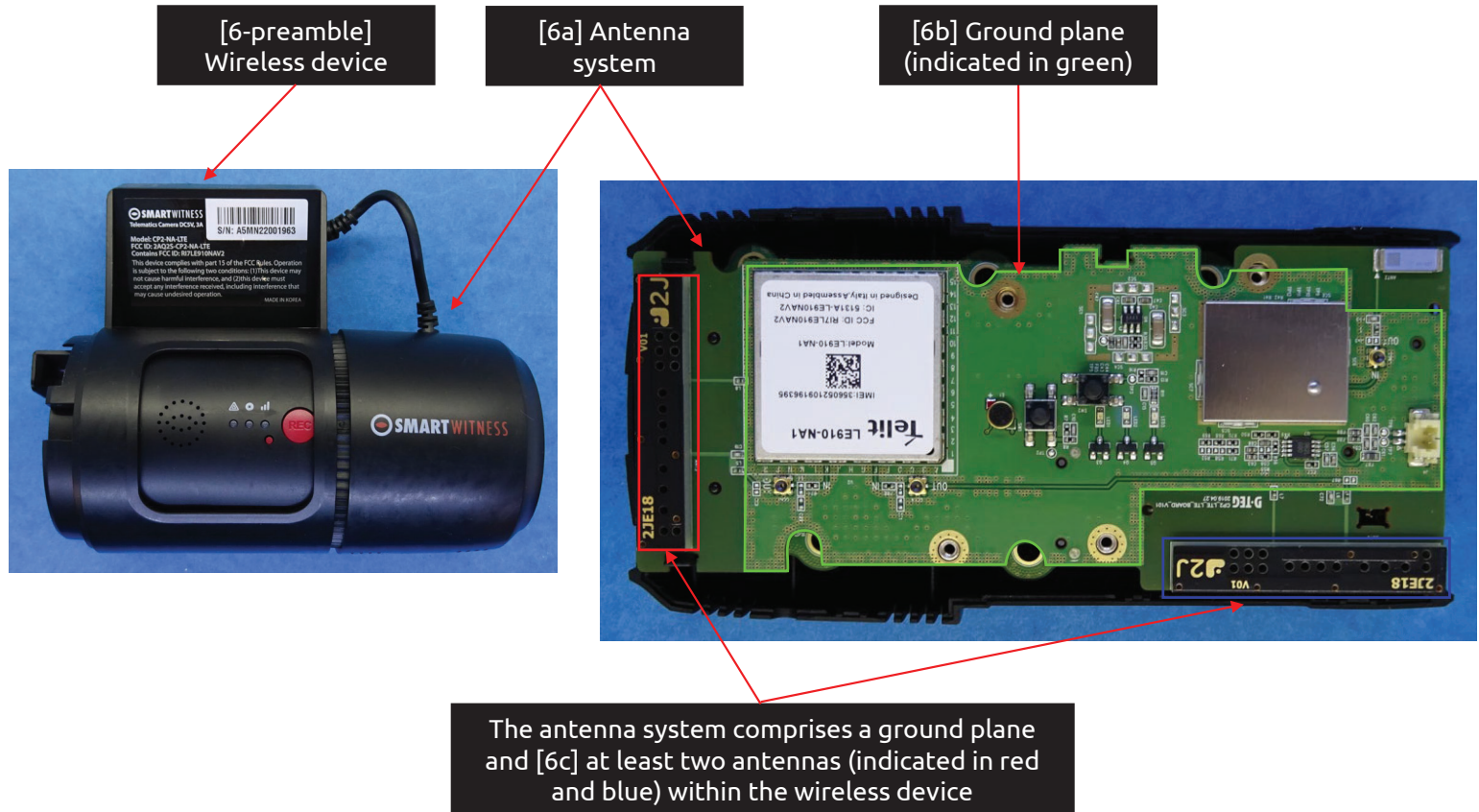
Source: User Manual

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Claim 6

[6-preamble] A wireless device comprising [6a] an antenna system comprising [6b] a ground plane and [6c] at least two antennas within the wireless device, the antenna system comprising:



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Claim 6

[6d] a first antenna configured to provide operation in at least four frequency bands being used by 4G communication standards, wherein

[6d] The antenna system comprises a first antenna (indicated in red) configured to provide operation in at least LTE 700(B12)/850(B5)/1700-2100(B4)/1900(B2)

Antenna system



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: User Manual

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Claim 6

[6e] at least two of the at least four frequency bands are contained within a first frequency range and [6f] at least two of the at least four frequency bands are contained within a second frequency range, [6g] the first frequency range being lower in frequency than the second frequency range,

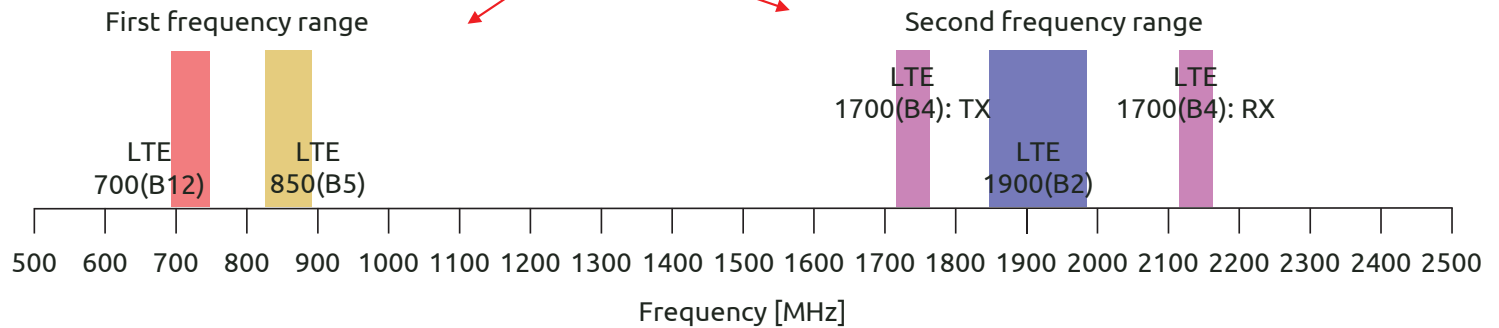
[6e] At least two of the at least four frequency bands are contained within a first frequency range (filled in red) and [6f] at least two of the at least four frequency bands are contained within a second frequency range (filled in blue)

Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: User Manual

[6g] The first frequency range being lower in frequency than the second frequency range



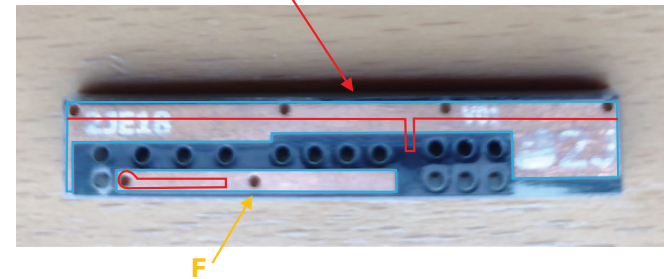
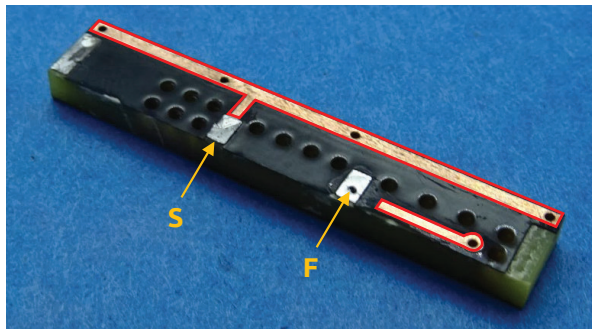
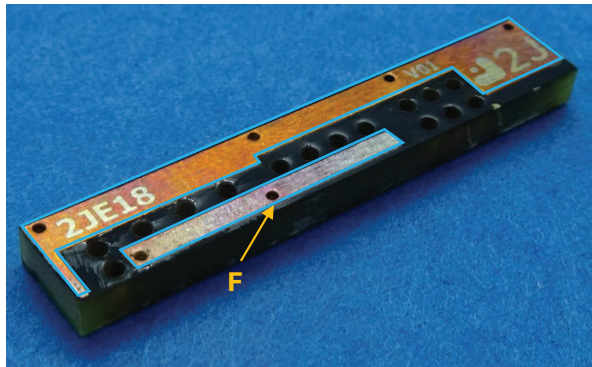
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Claim 6

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

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



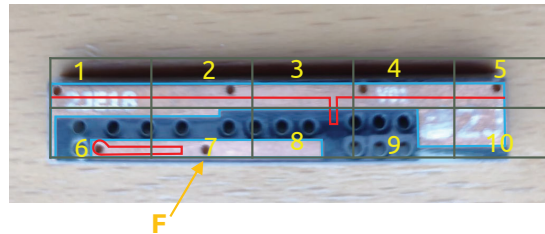
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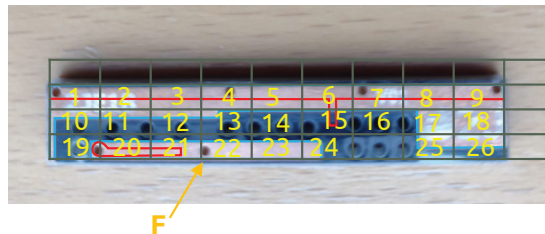
Claim 6

[6i] 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

[6i] 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



$N_2 = 26$ cells

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(26/10)}{\log(2)} = 1.38 \geq 1.20$$

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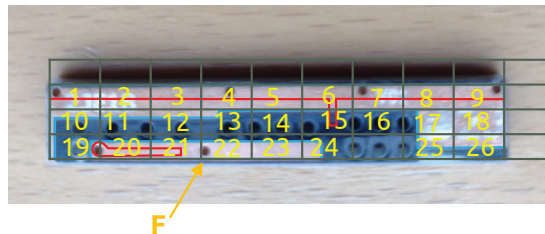
Claim 6

[6j] complexity factor F_{32} having a value of at least 1.35; and

[6j] The first antenna contour has a level of complexity defined by complexity factor F_{32} having a value of at least 1.35



$N_3 = 84 \text{ cells}$



$N_2 = 26 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(84/26)}{\log(2)} = 1.69 \geq 1.35$$

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Claim 6

[6k] a second antenna configured to operate in at least one frequency band being used by a 4G communication standard,

[6k] The antenna system comprises a second antenna (indicated in blue) configured to operate in at least LTE 700(B12)

Antenna system



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: User Manual

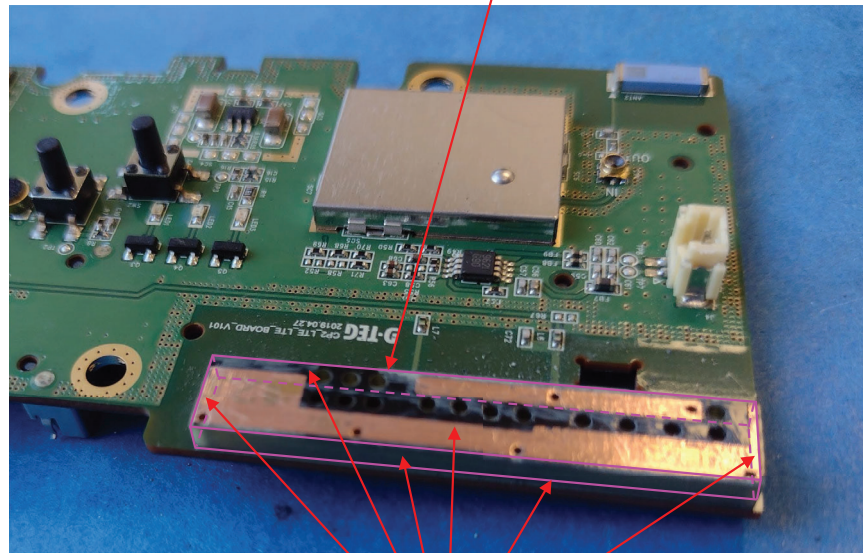
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Claim 6

[6l] the second antenna defining an antenna box that is a minimum-sized parallelepiped that completely encloses a volume of the second antenna and [6m] wherein each face of the minimum-sized parallelepiped is tangent to at least one point of the volume of the second antenna,

[6l] The second antenna defines an antenna box (outlined in pink) that is a minimum-sized parallelepiped that completely encloses a volume of the second antenna



[6m] Each face of the minimum-sized parallelepiped is tangent to at least one point of the volume of the second antenna

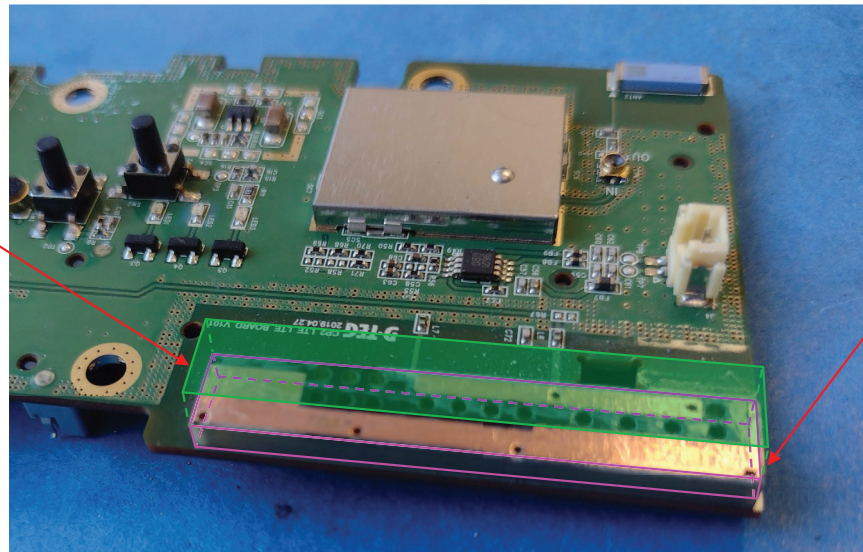
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Claim 6

[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

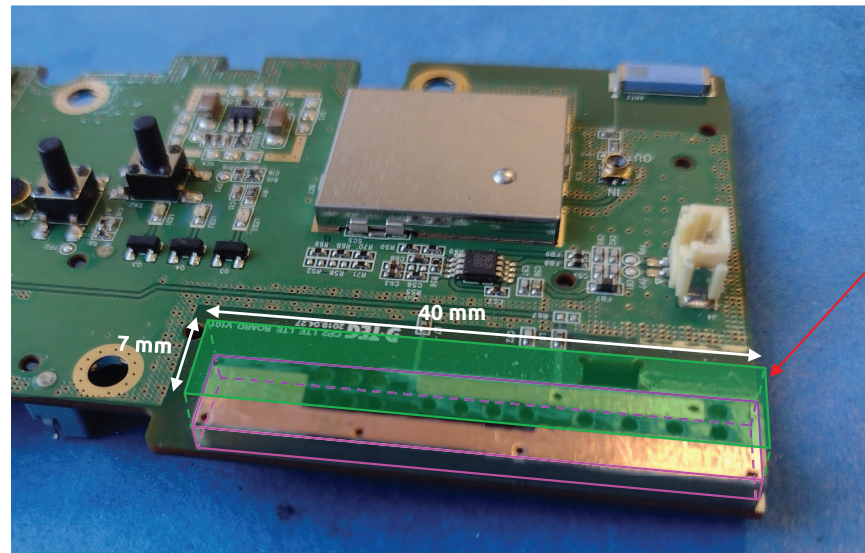
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Claim 6

[6p] 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, and

[6p] 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 $40/7 = 5.71 \geq 2$



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Claim 6

[6q] wherein at least one of the first and second antennas is close to a first short side of a ground plane rectangle enclosing the ground plane.

[6q] At least the first antenna is close 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)

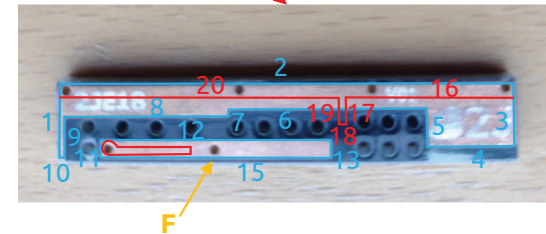
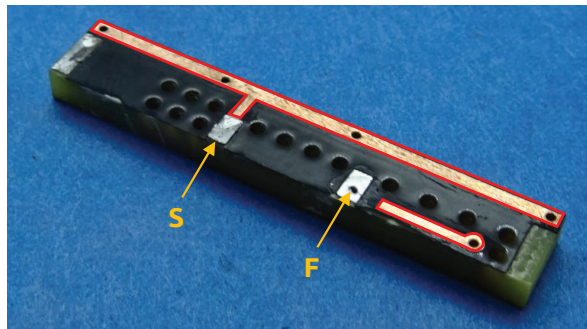
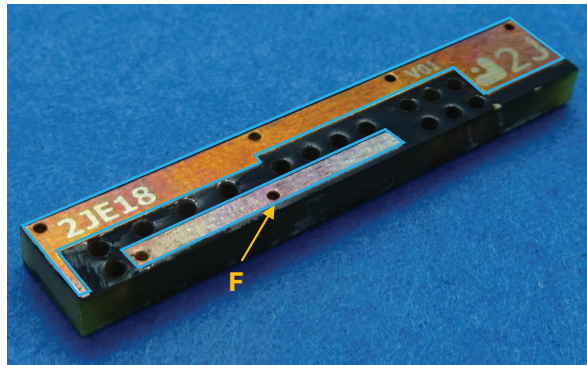
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Claim 7

[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



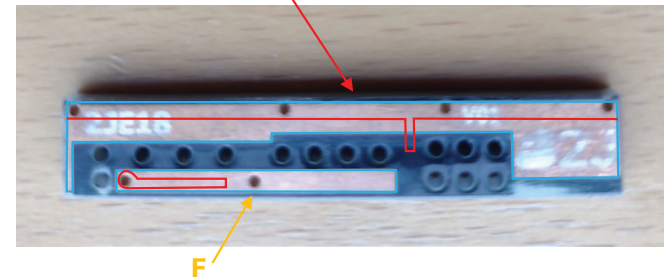
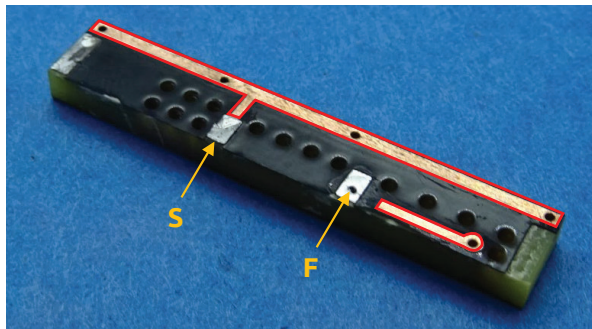
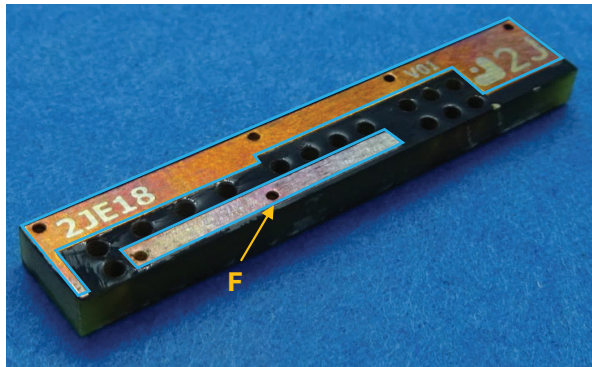
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Claim 9

[9a] The wireless device of claim 6, wherein the second antenna defines a second antenna contour comprising an entire perimeter of the second antenna,

[9a] The second antenna defines a second antenna contour (indicated in blue and red) comprising an entire perimeter of the second antenna

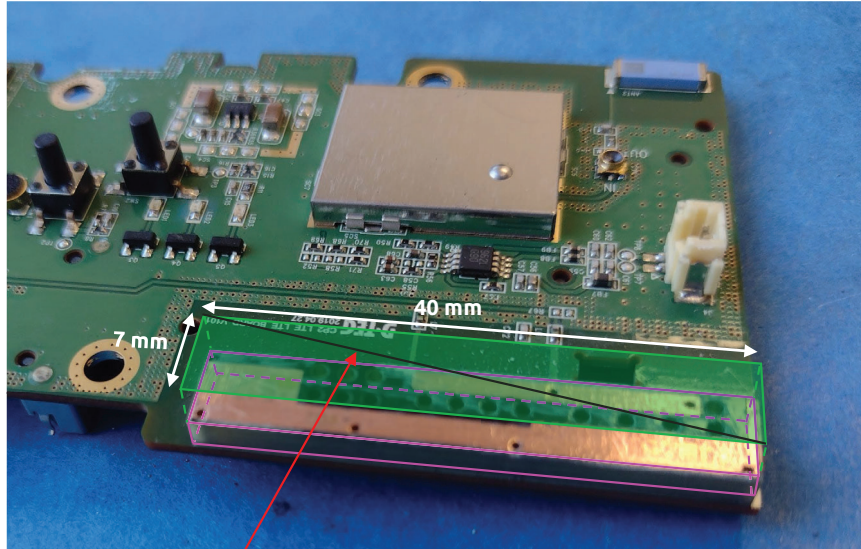


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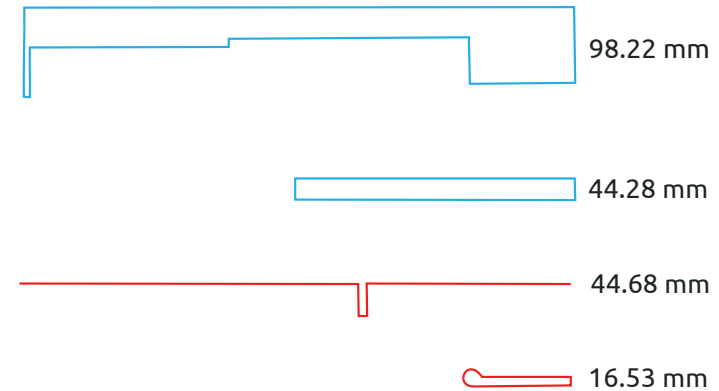
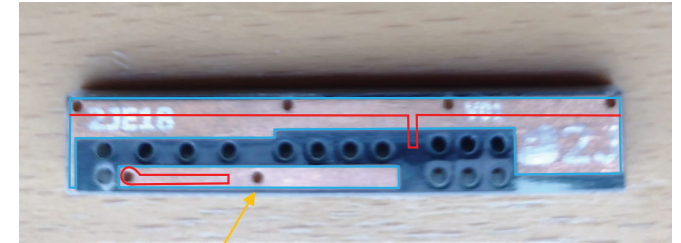
Claim 9

[9b] wherein a length of the second antenna contour is greater than four times a diagonal of the antenna rectangle.



Diagonal of the antenna rectangle = 40.61 mm

[9b] The length of the second antenna contour (203.71 mm) > 4*Diagonal of the antenna rectangle (4*40.61 = 162.43 mm)



Length of the second antenna contour = (98.22 + 44.28 + 44.68 + 16.53) = 203.71 mm

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Claim 10

[10a] The wireless device of claim 6, wherein the antenna system comprises a third antenna configured to provide operation in a wireless communication standard.

[10a] The antenna system comprises a third antenna (indicated in yellow) configured to provide operation in at least a wireless communication standard: WiFi 2.4 GHz



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850)
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

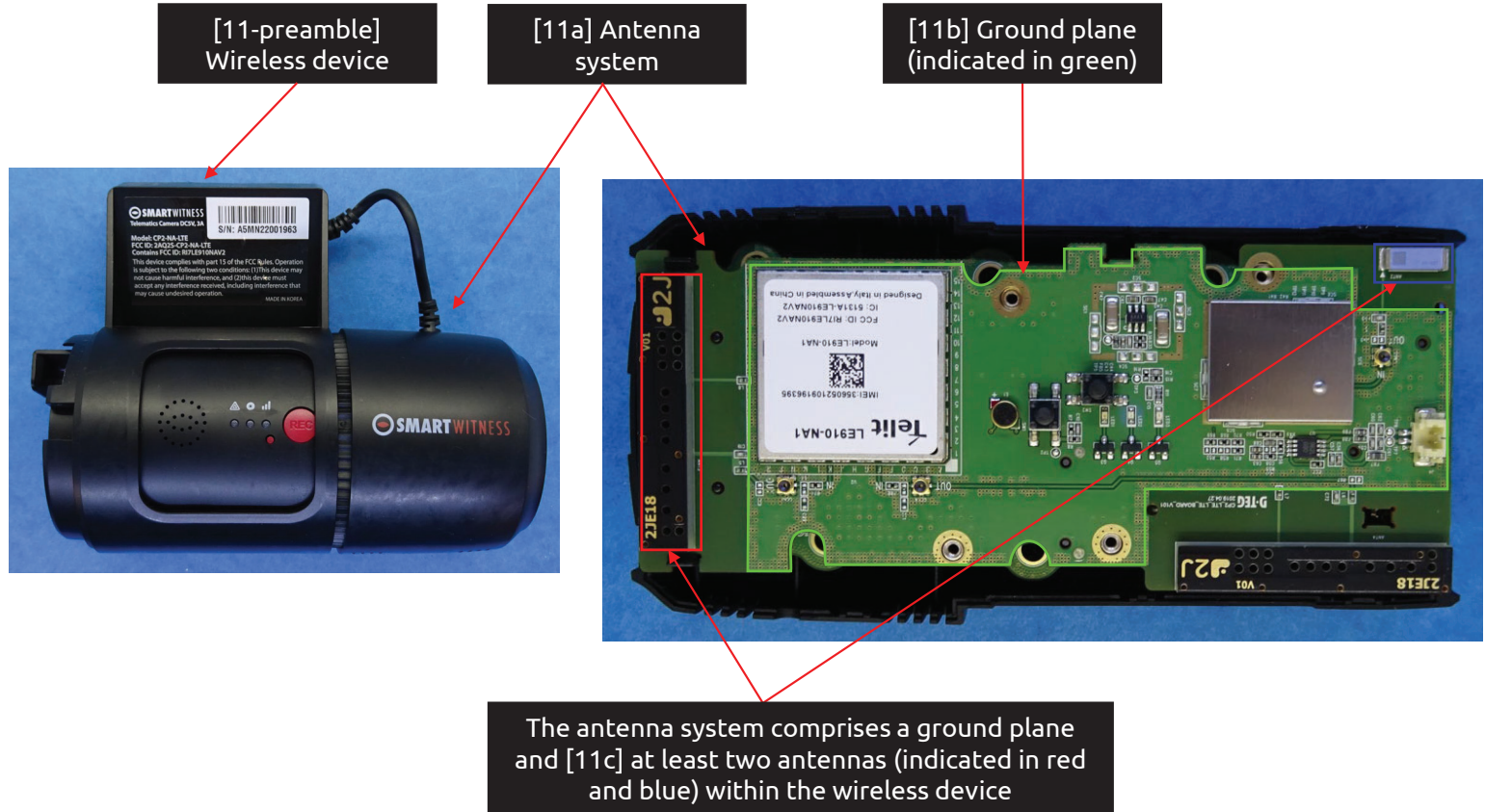
Source: User Manual

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Claim 11

[11-preamble] A wireless device comprising:
[11a] an antenna system comprising
[11b] a ground plane and
[11c] at least two antennas within the wireless device, the antenna system comprising:



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Claim 11

[11d] a first antenna configured to provide operation in at least three frequency bands being used by 4G communication standards,

[11d] The antenna system comprises a first antenna (indicated in red) configured to provide operation in at least LTE 700(B12)/1700-2100(B4)/1900(B2)

Antenna system



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

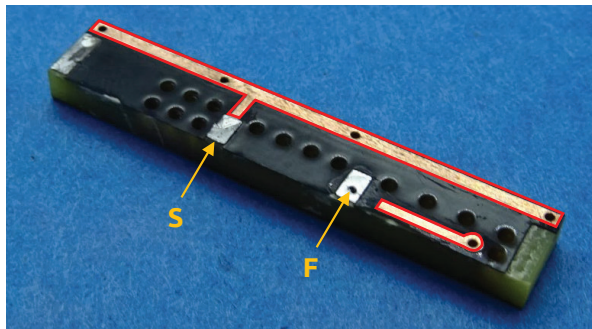
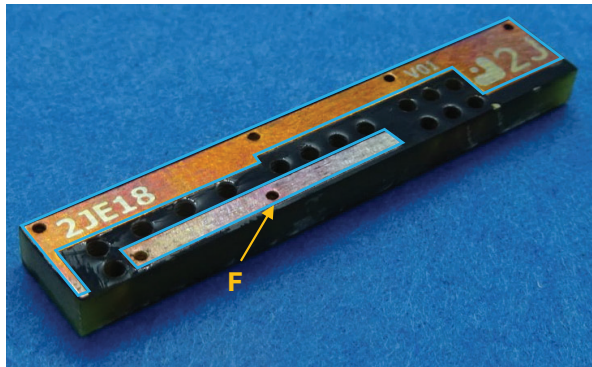
Source: User Manual

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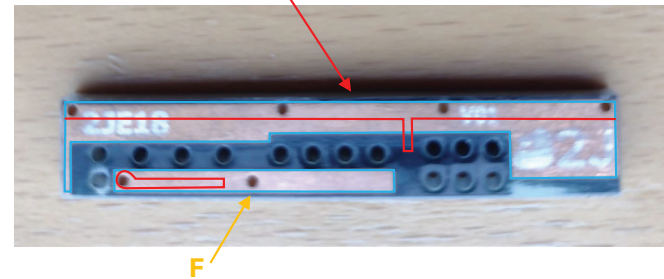
US 11,349,200 - SmartWitness CP2

Claim 11

[11e] the first antenna defining an antenna contour comprising an entire perimeter of the first antenna,



[11e] The first antenna defines a first antenna contour (indicated in blue and red) comprising an entire perimeter of the first antenna

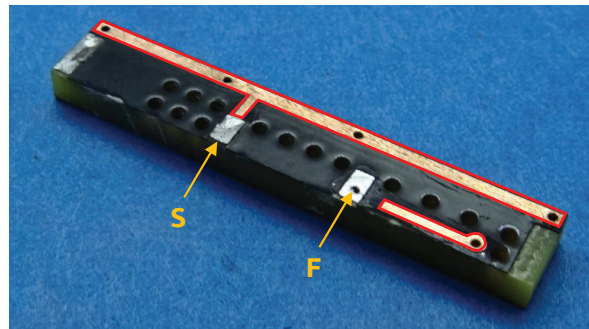
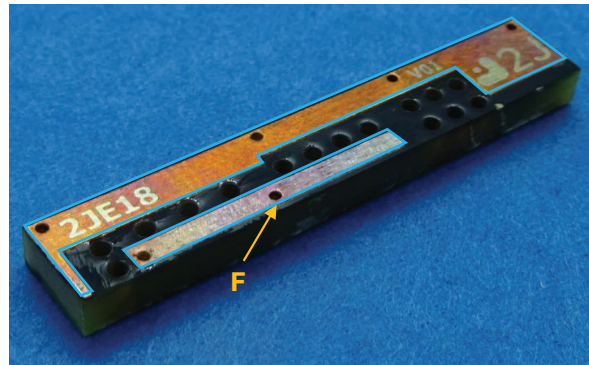


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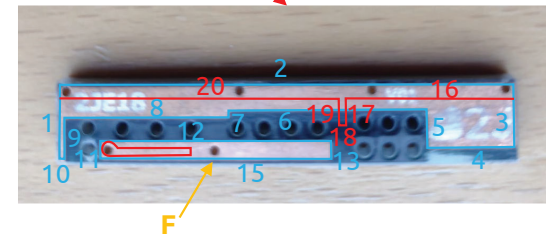
US 11,349,200 - SmartWitness CP2

Claim 11

[11f] the antenna contour comprising at least twenty segments,



[11f] The first antenna contour (indicated in blue and red) comprises at least 20 segments



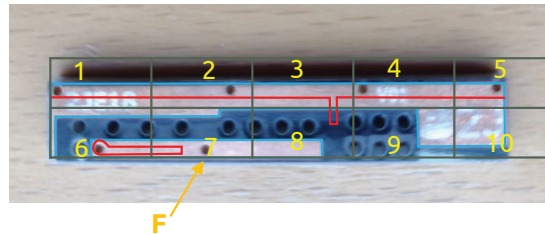
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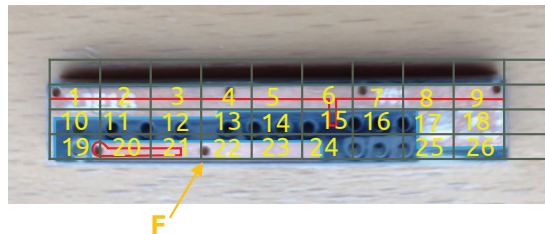
Claim 11

[11g] wherein the antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and

[11g] 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



$N_2 = 26$ cells

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(26/10)}{\log(2)} = 1.38 \geq 1.20$$

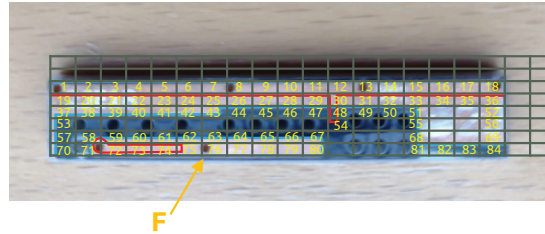
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Claim 11

[11h] complexity factor F_{32} having a value of at least 1.35, and

[11h] The first antenna contour has a level of complexity defined by complexity factor F_{32} having a value of at least 1.35



$N_3 = 84 \text{ cells}$



$N_2 = 26 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(84/26)}{\log(2)} = 1.69 \geq 1.35$$

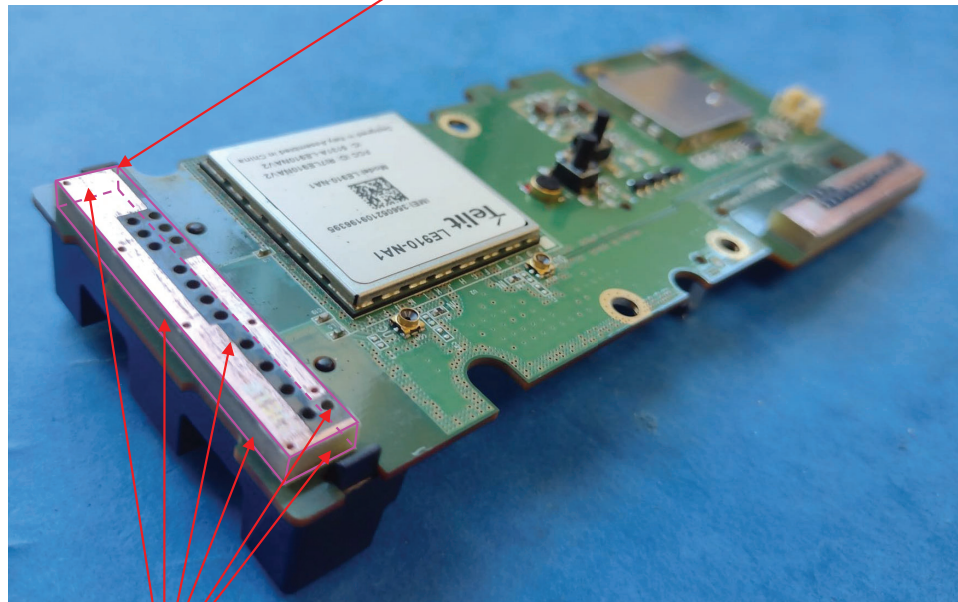
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Claim 11

[11i] wherein the first antenna defines an antenna box that is a minimum-sized parallelepiped that completely encloses a volume of the first antenna and
[11j] wherein each face of the minimum-sized parallelepiped is tangent to at least one point of the volume of the first antenna,

[11i] The first antenna defines an antenna box (outlined in pink) that is a minimum-sized parallelepiped that completely encloses a volume of the first antenna



[11j] Each face of the minimum-sized parallelepiped is tangent to at least one point of the volume of the first antenna

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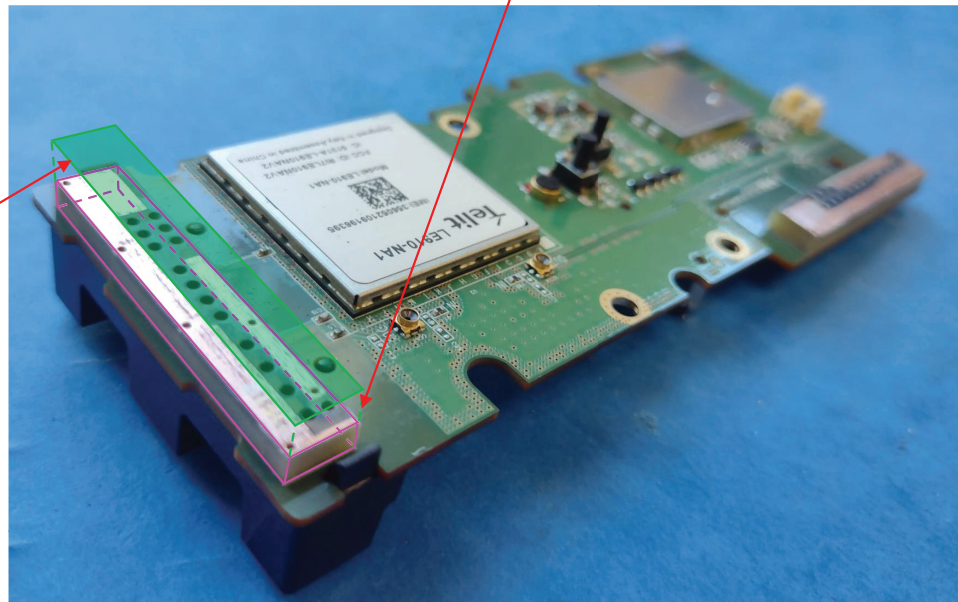
US 11,349,200 - SmartWitness CP2

Claim 11

[11k] an orthogonal projection of the antenna box along a normal to a face with a largest area of the first antenna defining [11l] an antenna rectangle,

[11k] An orthogonal projection of the antenna box along a normal to a face* with a largest area of the first antenna

[11l] Antenna rectangle (filled in green)



*Normal to a face means perpendicular to the face

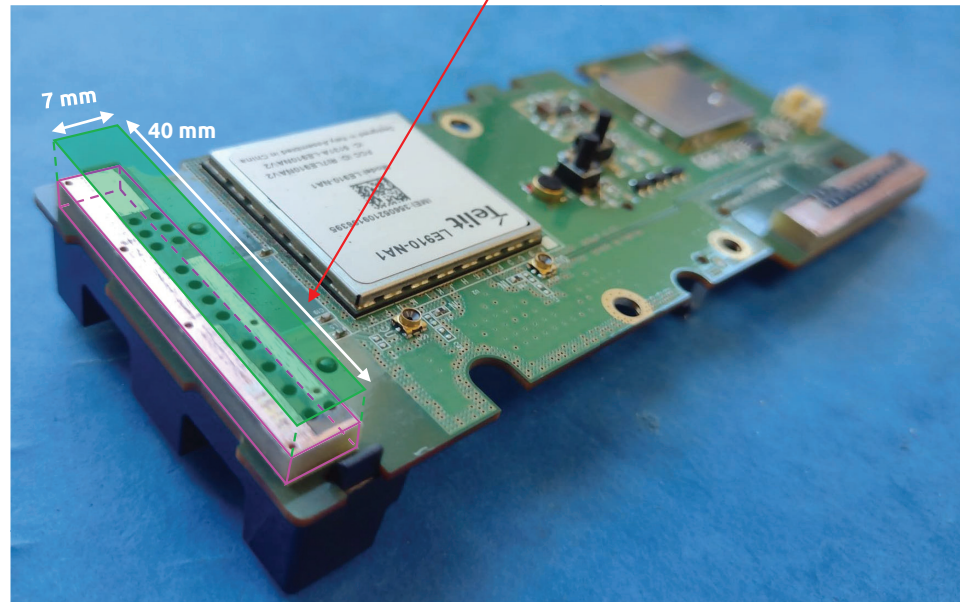
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Claim 11

[11m] an aspect ratio of the antenna rectangle being defined as a ratio between a width and a height of the antenna rectangle, wherein the aspect ratio has a value of at least 2; and

[11m] 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 $40/7 = 5.71 \geq 2$



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Claim 11

[11n] a second antenna configured to provide operation in a first wireless service, [11o] the second antenna being proximate to a side of a ground plane rectangle enclosing the ground plane.

[11n] The antenna system comprises a second antenna (indicated in blue) configured to provide operation in at least a first wireless service: WiFi 2.4 GHz, and [11o] is proximate to a side of a ground plane rectangle (indicated with a dashed green line) enclosing the ground plane



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: User Manual

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Claim 12

[12a] The wireless device of claim 11, wherein the first antenna is configured to support at least four frequency bands.

[12a] The first antenna (indicated in red) is configured to support at least LTE 700(B12)/850(B5)/1700-2100(B4)/1900(B2)



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: User Manual

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Claim 13

[13a] The wireless device of claim 11, wherein the first wireless service is a WiFi communication standard.

[13a] The first wireless service is a WiFi communication standard



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

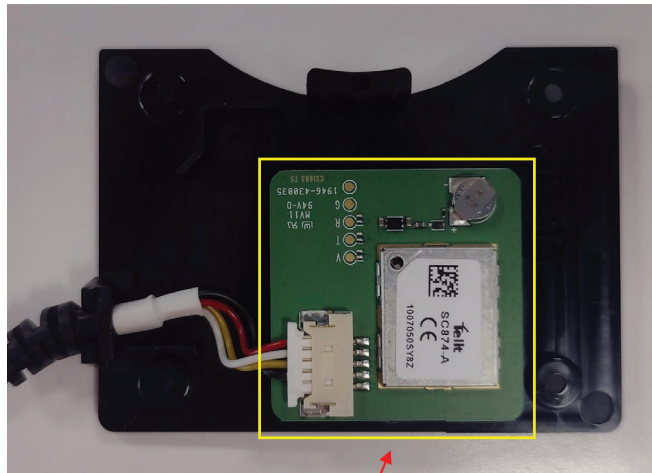
Source: User Manual

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Claim 15

[15a] The wireless device of claim 11, wherein the antenna system comprises a third antenna.



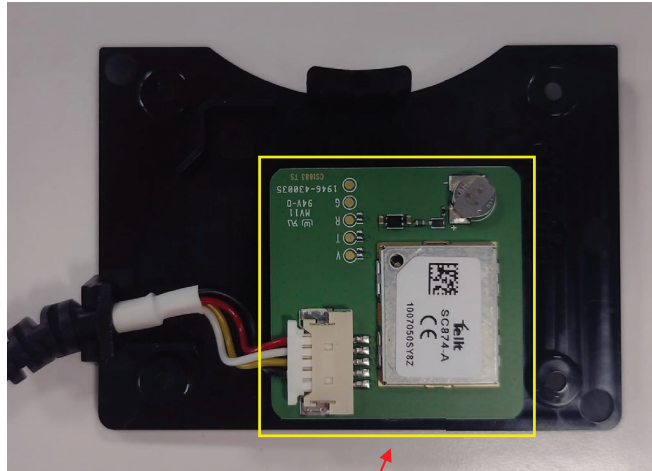
[15a] The antenna system comprises a third antenna (indicated in yellow)

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Claim 17

[17a] The wireless device of claim 15, wherein the third antenna is configured to provide operation in a second wireless service.



[17a] The third antenna (indicated in yellow) configured to provide operation in at least a second wireless service: GPS

GPS / GLONASS	Internal GPS / GLONASS
G-Sensor	Internal 3-axis G-sensor
Gyro	3 axis (X,Y,Z), output rate: 100 Hz
Alarm In / Out	2 x Alarm in 1 x Alarm out

Source: User Manual

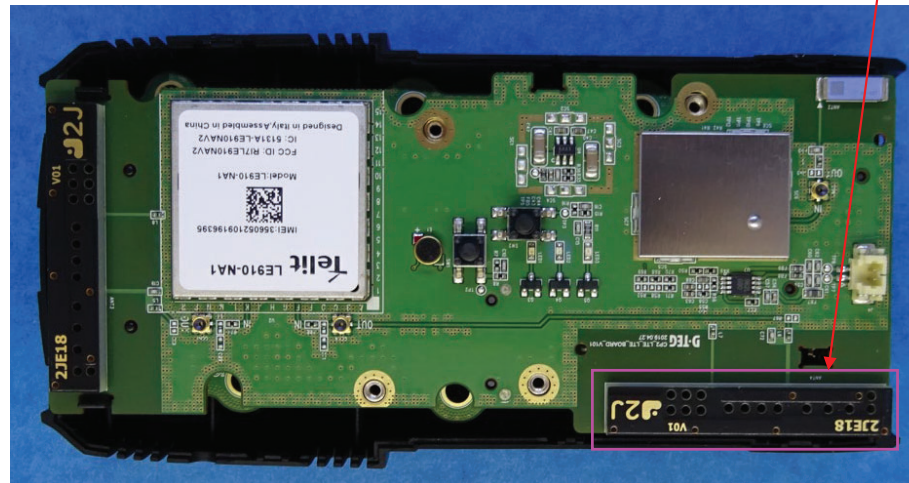
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Claim 19

[19a] The wireless device of claim 15, wherein the antenna system comprises a fourth antenna.

[19a] The antenna system comprises a fourth antenna (indicated in pink)



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SmartWitness CP2

Infringement where the diversity antenna is considered the first antenna

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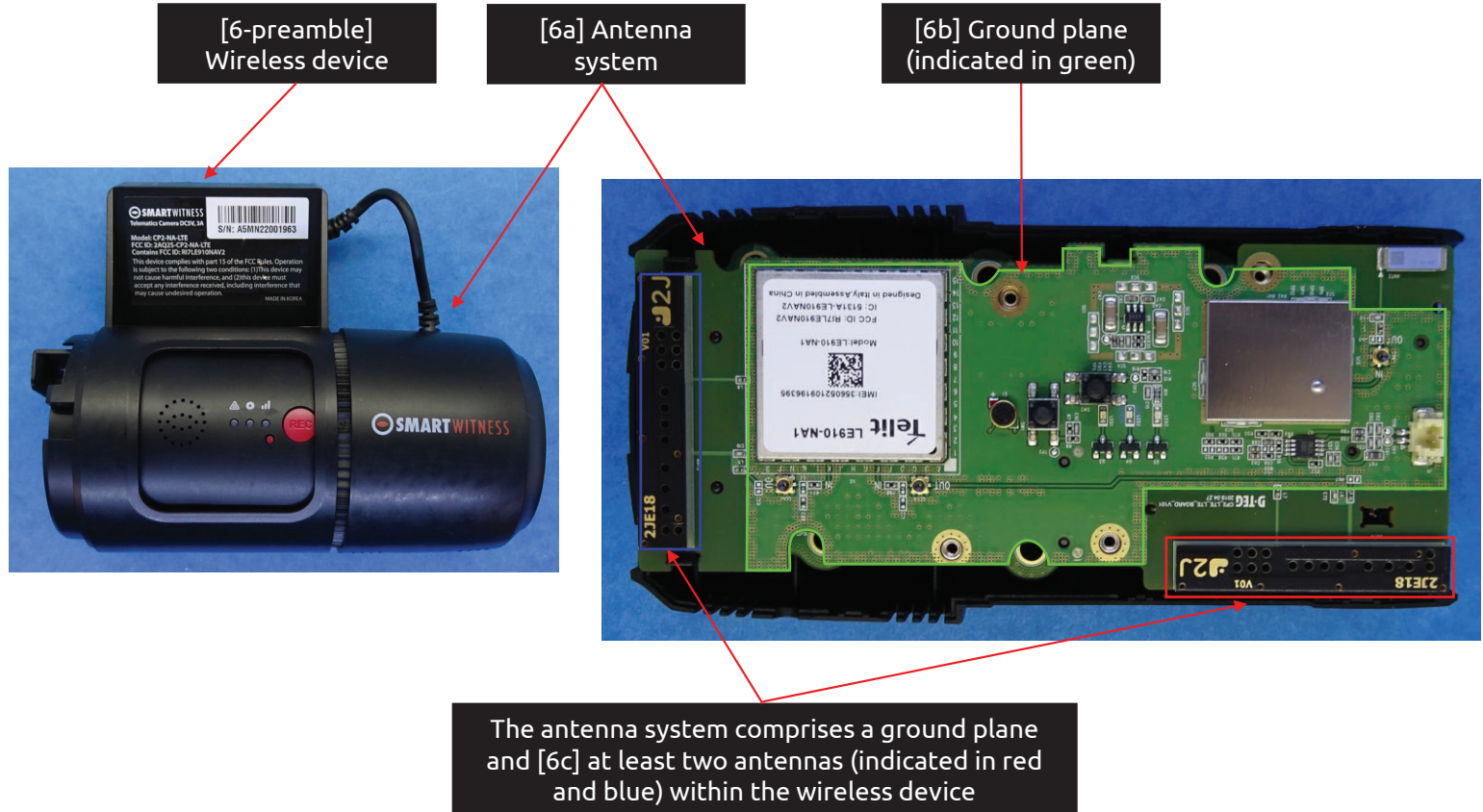
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Claim 6

[6-preamble] A wireless device comprising [6a] an antenna system comprising [6b] a ground plane and [6c] at least two antennas within the wireless device, the antenna system comprising:



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Claim 6

[6d] a first antenna configured to provide operation in at least four frequency bands being used by 4G communication standards, wherein

[6d] The antenna system comprises a first antenna (indicated in red) configured to provide operation in at least LTE 700(B12)/850(B5)/2100(B4)/1900(B2)

Antenna system



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: User Manual

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Claim 6

[6e] at least two of the at least four frequency bands are contained within a first frequency range and [6f] at least two of the at least four frequency bands are contained within a second frequency range, [6g] the first frequency range being lower in frequency than the second frequency range,

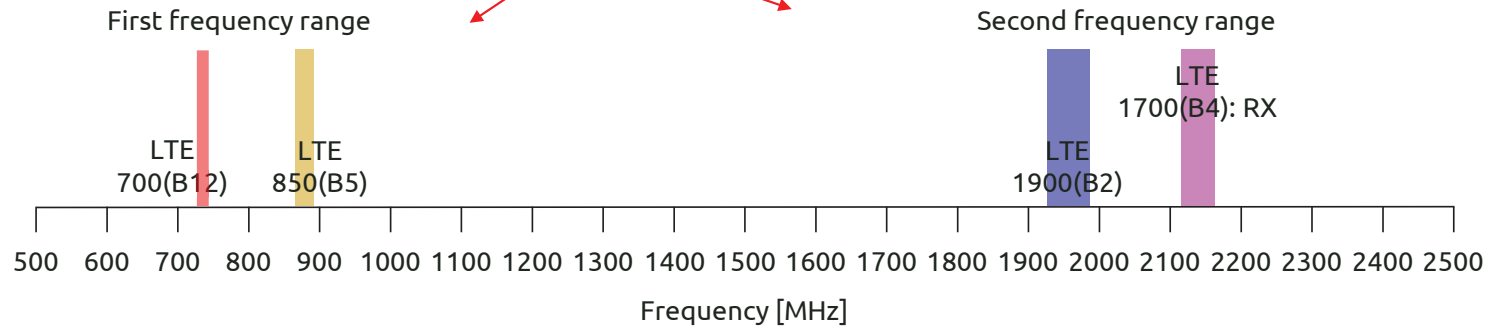
[6e] At least two of the at least four frequency bands are contained within a first frequency range (filled in red) and [6f] at least two of the at least four frequency bands are contained within a second frequency range (filled in blue)

Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS) B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: User Manual

[6g] The first frequency range being lower in frequency than the second frequency range

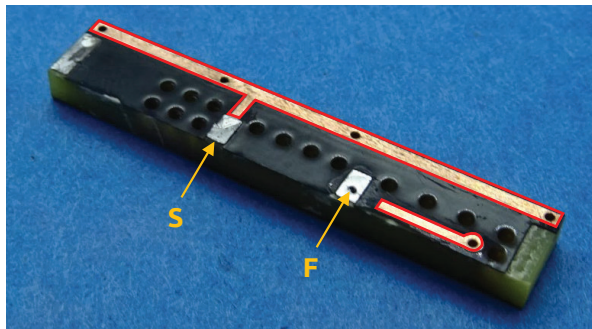
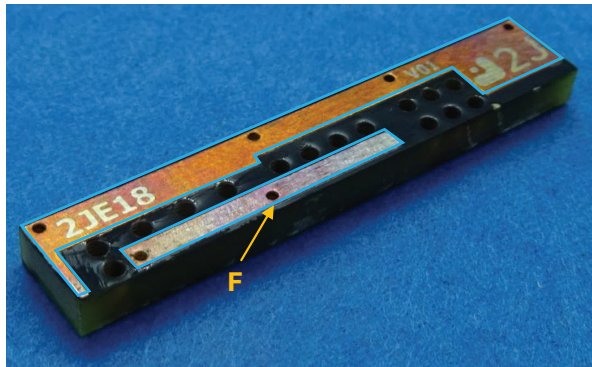


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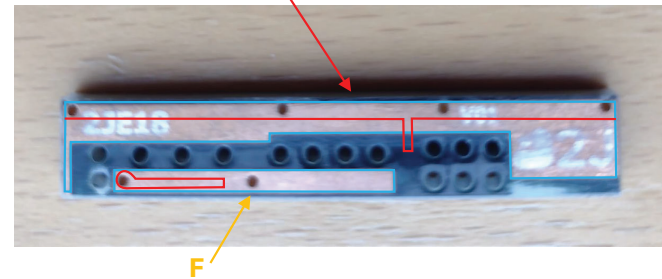
US 11,349,200 - SmartWitness CP2

Claim 6

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



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



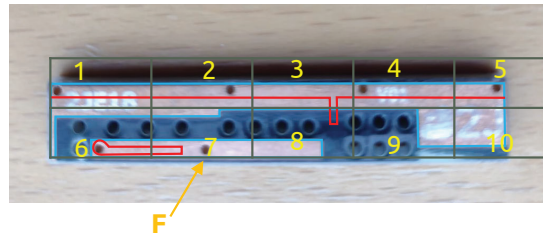
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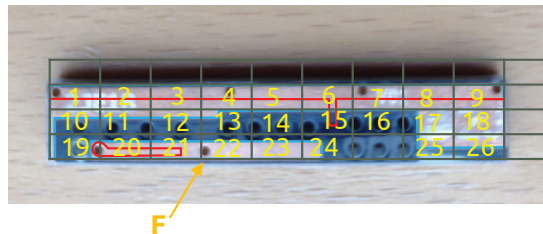
Claim 6

[6i] 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

[6i] 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



$N_2 = 26$ cells

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(26/10)}{\log(2)} = 1.38 \geq 1.20$$

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Claim 6

[6j] complexity factor F_{32} having a value of at least 1.35; and

[6j] The first antenna contour has a level of complexity defined by complexity factor F_{32} having a value of at least 1.35



$N_3 = 84 \text{ cells}$



$N_2 = 26 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(84/26)}{\log(2)} = 1.69 \geq 1.35$$

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Claim 6

[6k] a second antenna configured to operate in at least one frequency band being used by a 4G communication standard,

Antenna system

[6k] The antenna system comprises a second antenna (indicated in blue) configured to operate in at least LTE 700(B12)



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: User Manual

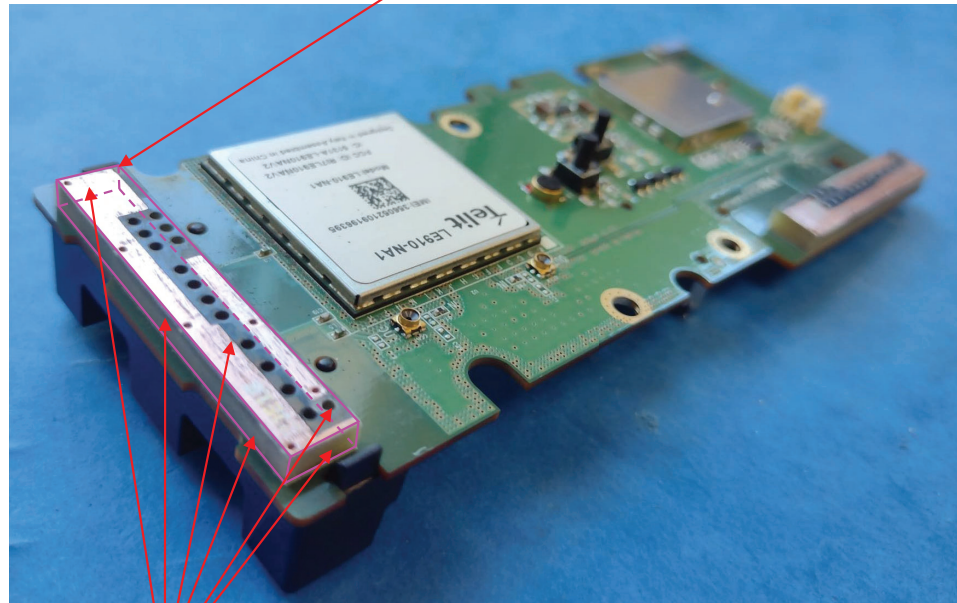
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Claim 6

[6l] the second antenna defining an antenna box that is a minimum-sized parallelepiped that completely encloses a volume of the second antenna and [6m] wherein each face of the minimum-sized parallelepiped is tangent to at least one point of the volume of the second antenna,

[6l] The second antenna defines an antenna box (outlined in pink) that is a minimum-sized parallelepiped that completely encloses a volume of the second antenna



[6m] Each face of the minimum-sized parallelepiped is tangent to at least one point of the volume of the second antenna

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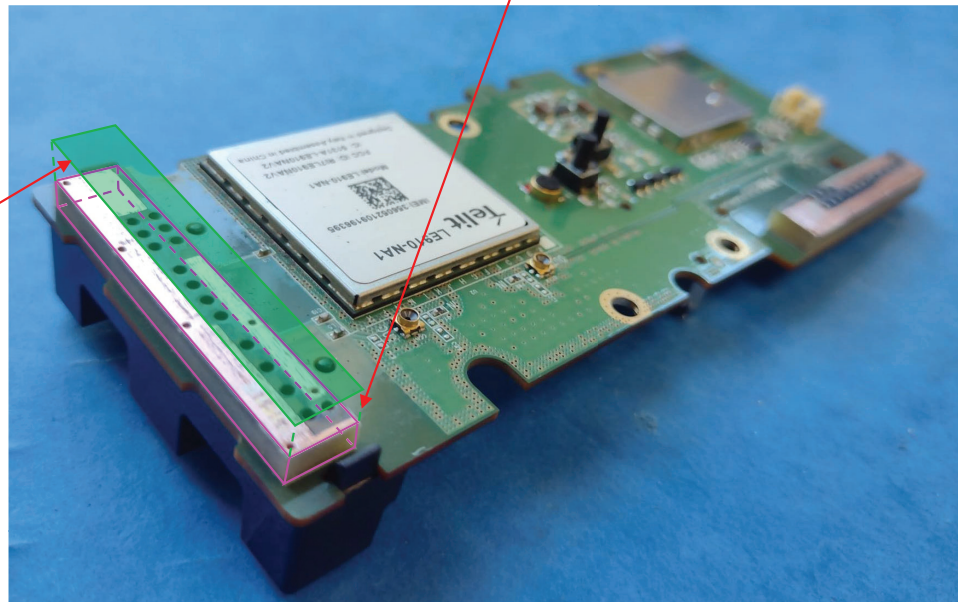
US 11,349,200 - SmartWitness CP2

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

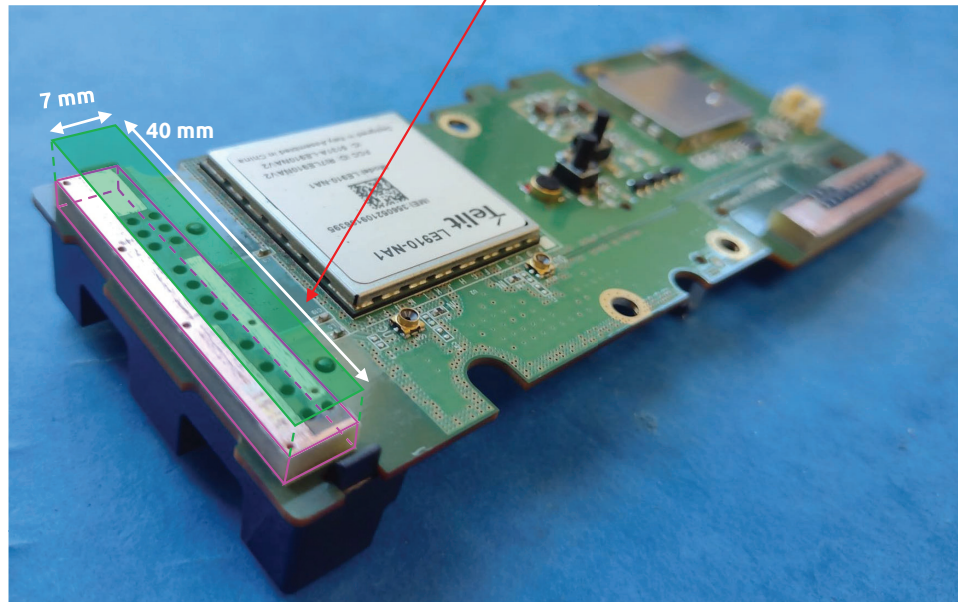
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Claim 6

[6p] 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, and

[6p] 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 $40/7 = 5.71 \geq 2$



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Claim 6

[6q] wherein at least one of the first and second antennas is close to a first short side of a ground plane rectangle enclosing the ground plane.

[6q] At least the second antenna is close 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)

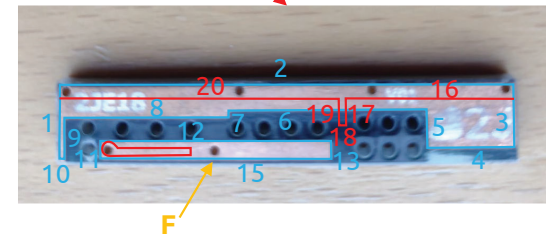
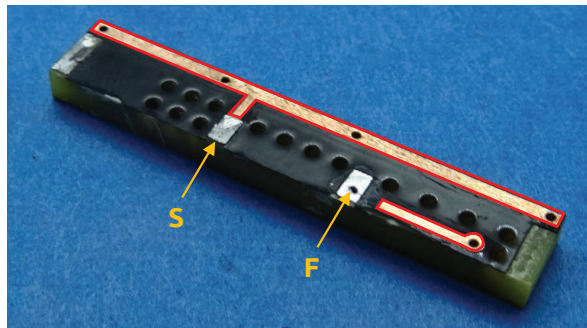
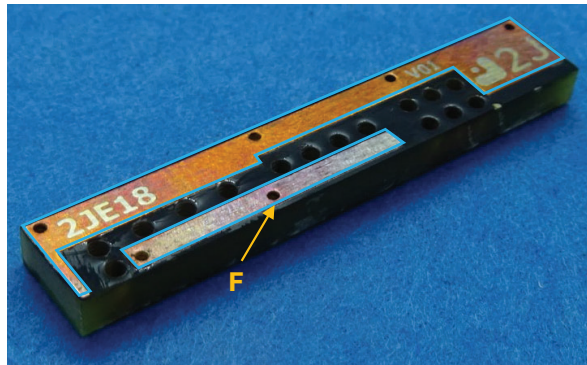
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Claim 7

[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



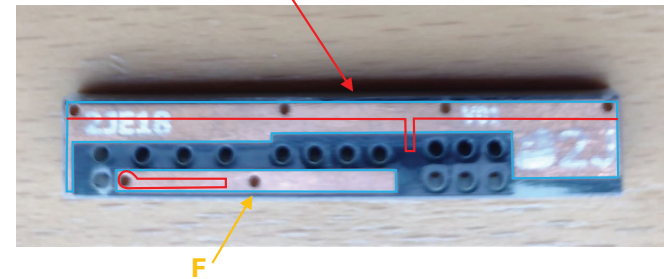
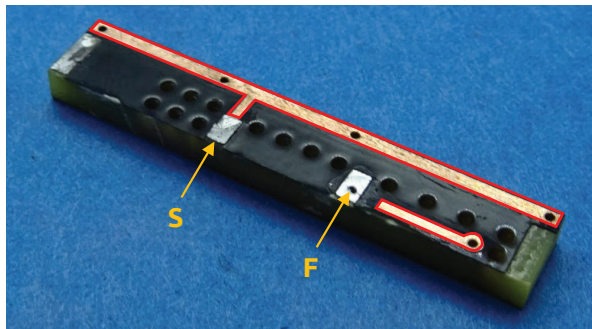
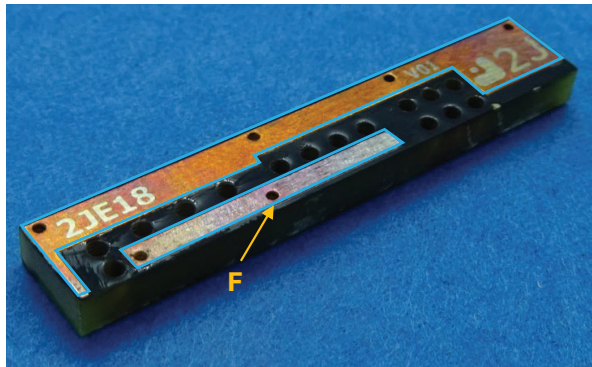
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Claim 9

[9a] The wireless device of claim 6, wherein the second antenna defines a second antenna contour comprising an entire perimeter of the second antenna,

[9a] The second antenna defines a second antenna contour (indicated in blue and red) comprising an entire perimeter of the second antenna

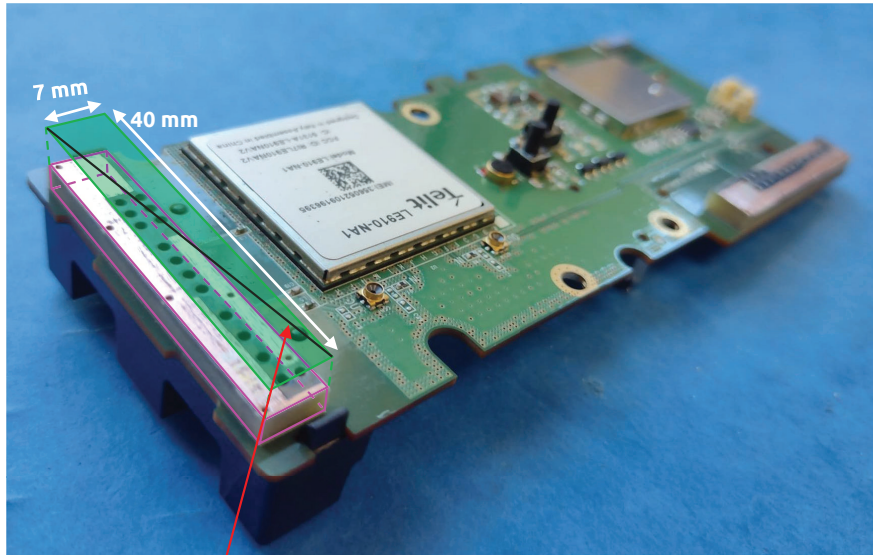


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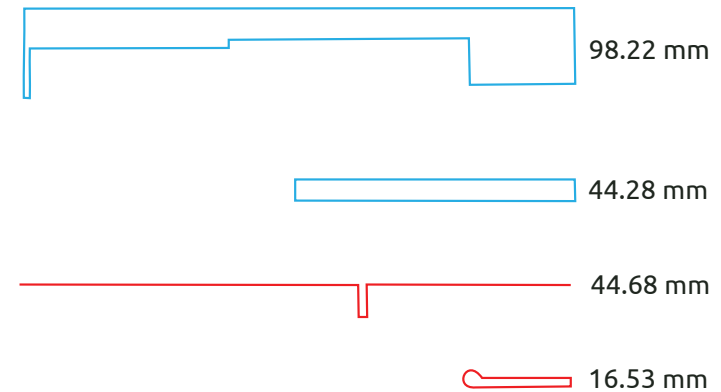
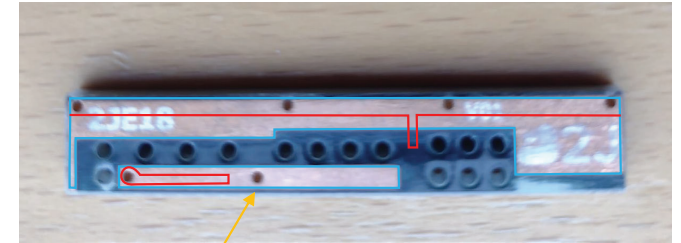
Claim 9

[9b] wherein a length of the second antenna contour is greater than four times a diagonal of the antenna rectangle.



Diagonal of the antenna rectangle = 40.61 mm

[9b] The length of the second antenna contour (203.71 mm) > 4*Diagonal of the antenna rectangle (4*40.61 = 162.43 mm)



Length of the second antenna contour = (98.22 + 44.28 + 44.68 + 16.53) = 203.71 mm

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Claim 10

[10a] The wireless device of claim 6, wherein the antenna system comprises a third antenna configured to provide operation in a wireless communication standard.

[10a] The antenna system comprises a third antenna (indicated in yellow) configured to provide operation in at least a wireless communication standard: WiFi 2.4 GHz



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

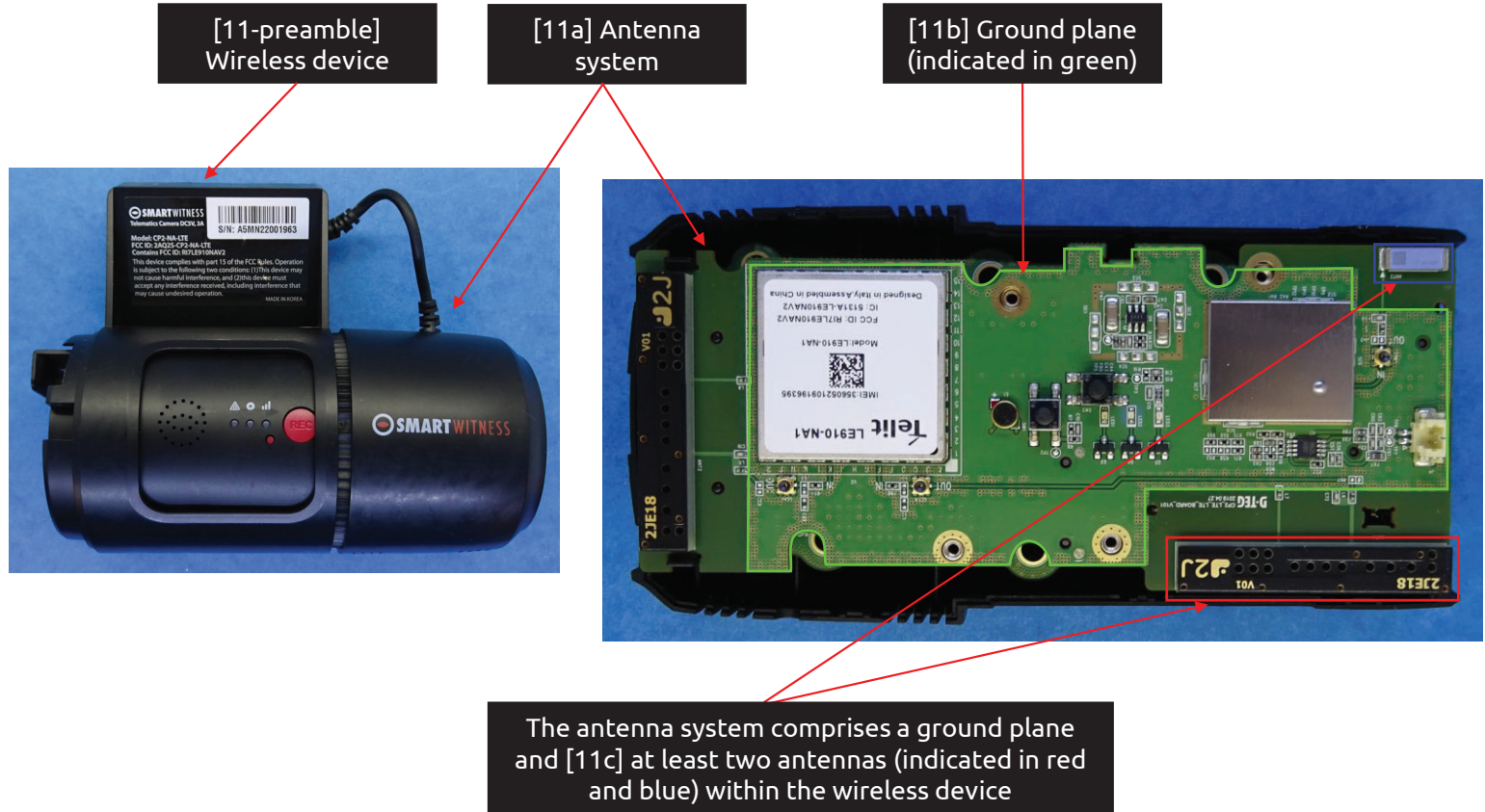
Source: User Manual

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Claim 11

[11-preamble] A wireless device comprising:
[11a] an antenna system comprising
[11b] a ground plane and
[11c] at least two antennas within the wireless device, the antenna system comprising:



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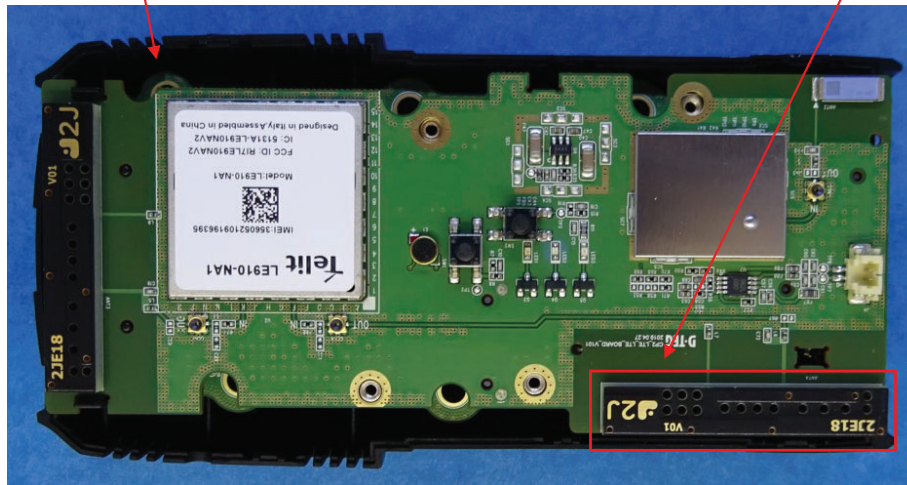
US 11,349,200 - SmartWitness CP2

Claim 11

[11d] a first antenna configured to provide operation in at least three frequency bands being used by 4G communication standards,

[11d] The antenna system comprises a first antenna (indicated in red) configured to provide operation in at least LTE 700(B12)/2100(B4)/1900(B2)

Antenna system



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

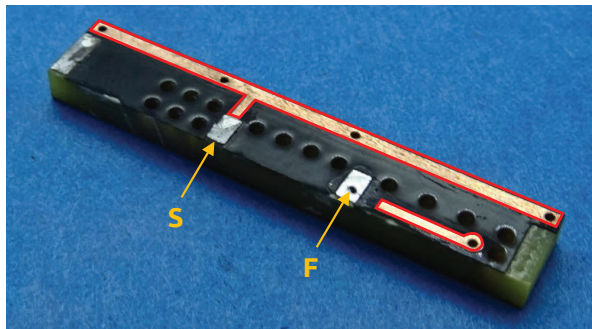
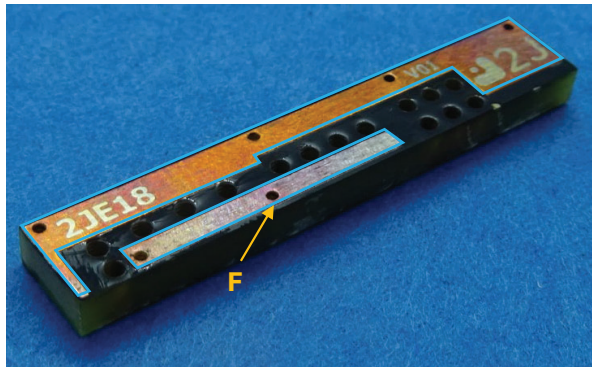
Source: User Manual

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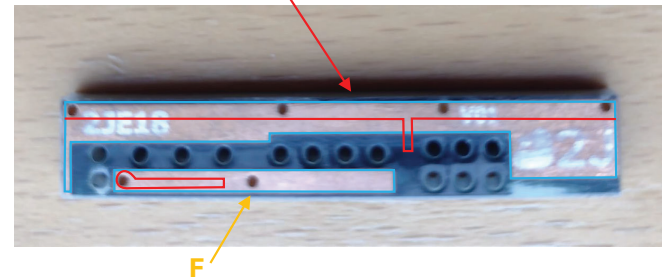
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Claim 11

[11e] the first antenna defining an antenna contour comprising an entire perimeter of the first antenna,



[11e] The first antenna defines a first antenna contour (indicated in blue and red) comprising an entire perimeter of the first antenna

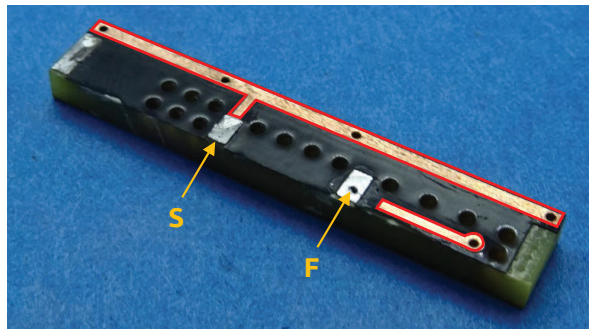
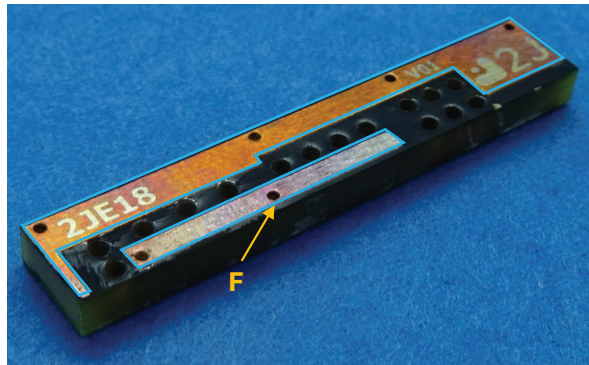


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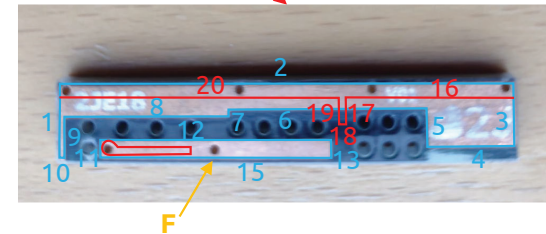
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Claim 11

[11f] the antenna contour comprising at least twenty segments,



[11f] The first antenna contour (indicated in blue and red) comprises at least 20 segments



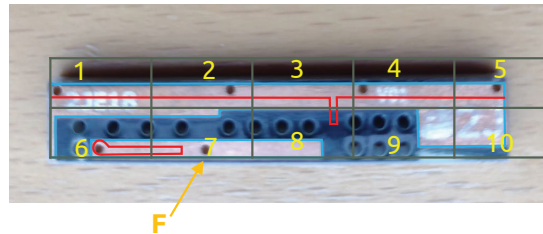
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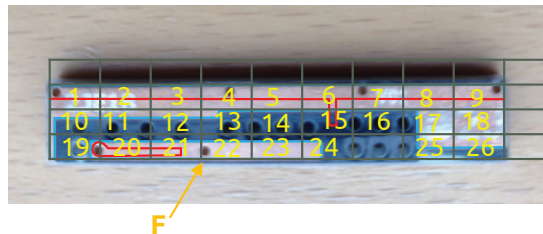
Claim 11

[11g] wherein the antenna contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and

[11g] 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



$N_2 = 26$ cells

$$F_{21} = -\frac{\log(N_2) - \log(N_1)}{\log\left(\frac{1}{2}\right)} = \frac{\log(26/10)}{\log(2)} = 1.38 \geq 1.20$$

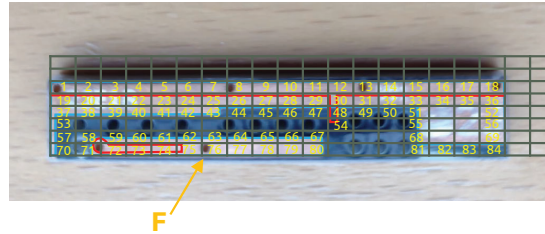
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Claim 11

[11h] complexity factor F_{32} having a value of at least 1.35, and

[11h] The first antenna contour has a level of complexity defined by complexity factor F_{32} having a value of at least 1.35



$N_3 = 84 \text{ cells}$



$N_2 = 26 \text{ cells}$

$$F_{32} = -\frac{\log(N_3) - \log(N_2)}{\log\left(\frac{1}{2}\right)} = \frac{\log(84/26)}{\log(2)} = 1.69 \geq 1.35$$

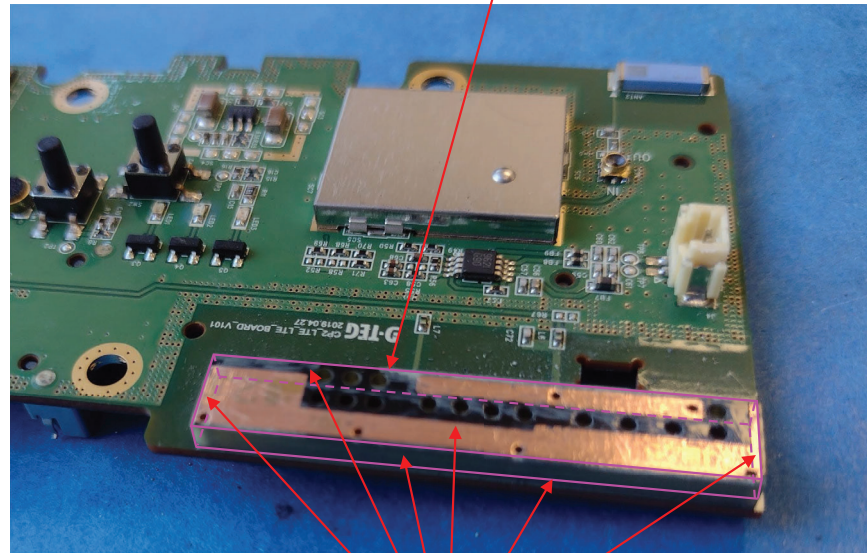
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Claim 11

[11i] wherein the first antenna defines an antenna box that is a minimum-sized parallelepiped that completely encloses a volume of the first antenna and
[11j] wherein each face of the minimum-sized parallelepiped is tangent to at least one point of the volume of the first antenna,

[11i] The first antenna defines an antenna box (outlined in pink) that is a minimum-sized parallelepiped that completely encloses a volume of the first antenna



[11j] Each face of the minimum-sized parallelepiped is tangent to at least one point of the volume of the first antenna

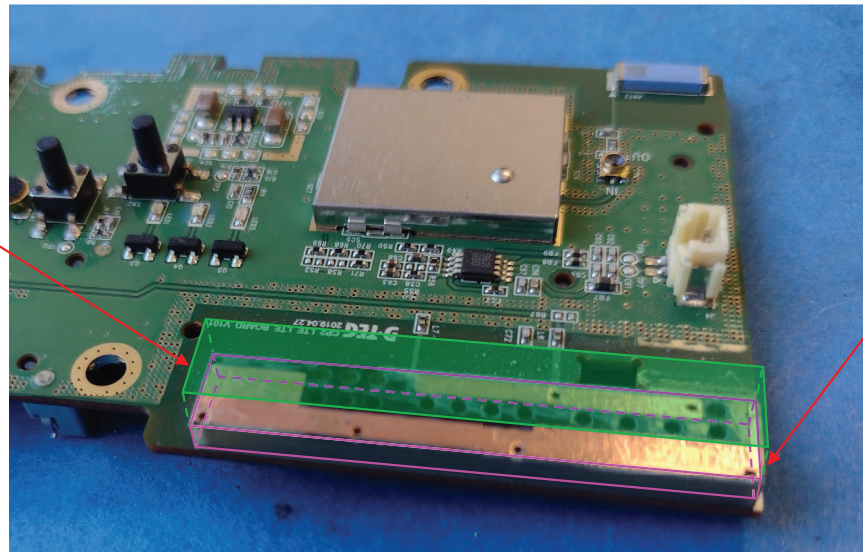
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Claim 11

[11k] an orthogonal projection of the antenna box along a normal to a face with a largest area of the first antenna defining [11l] an antenna rectangle,

[11l] Antenna rectangle (filled in green)



[11k] An orthogonal projection of the antenna box along a normal to a face* with a largest area of the first antenna

*Normal to a face means perpendicular to the face

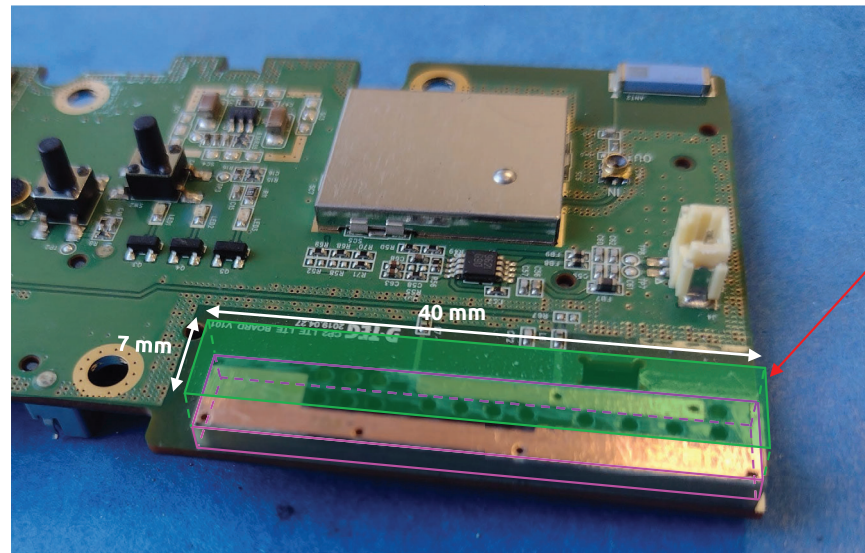
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Claim 11

[11m] an aspect ratio of the antenna rectangle being defined as a ratio between a width and a height of the antenna rectangle, wherein the aspect ratio has a value of at least 2; and

[11m] 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 $40/7 = 5.71 \geq 2$



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Claim 11

[11n] a second antenna configured to provide operation in a first wireless service, [11o] the second antenna being proximate to a side of a ground plane rectangle enclosing the ground plane.

[11n] The antenna system comprises a second antenna (indicated in blue) configured to provide operation in at least a first wireless service: WiFi 2.4 GHz, and [11o] is proximate to a side of a ground plane rectangle (indicated with a dashed green line) enclosing the ground plane



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: User Manual

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Claim 12

[12a] The wireless device of claim 11, wherein the first antenna is configured to support at least four frequency bands.

[12a] The first antenna (indicated in red) is configured to support at least LTE 700(B12)/850(B5)/2100(B4)/1900(B2)



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

Source: User Manual

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Claim 13

[13a] The wireless device of claim 11, wherein the first wireless service is a WiFi communication standard.

[13a] The first wireless service is a WiFi communication standard



Connectivity

Cellular	CP2-NA-LTE: [CAT1] B2 (1900), B4 (AWS), B5 (850), B12 (700AC), B13 (700C); [3G] B2 (1900), B5 (850) CP2-EU-LTE: [CAT4] B1 (2100), B3 (1800), B7 (2600), B8 (900), B20 (800); [3G] B2 (2100), B8 (900) CP2-AP-LTE: [CAT1] B1, B3, B5, B8, B9, B18 (26), B19, B28; [3G] B1, B5, B6, B19, B8
Max Data Rate	UL: 5Mbps, DL: 10Mbps
WiFi	802.11 b/g/n
Bluetooth	Bluetooth 4.2

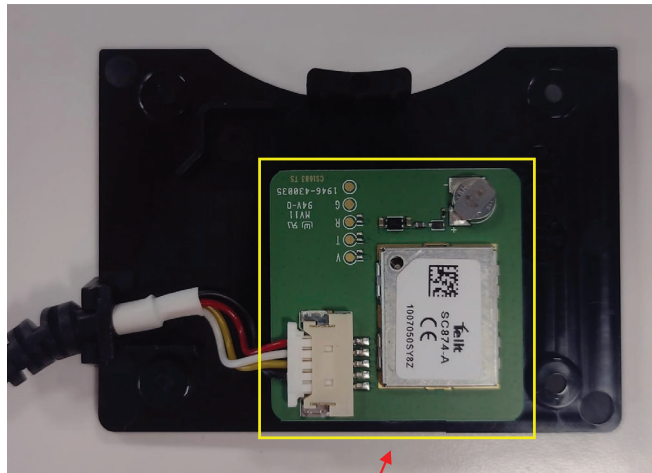
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Claim 15

[15a] The wireless device of claim 11, wherein the antenna system comprises a third antenna.



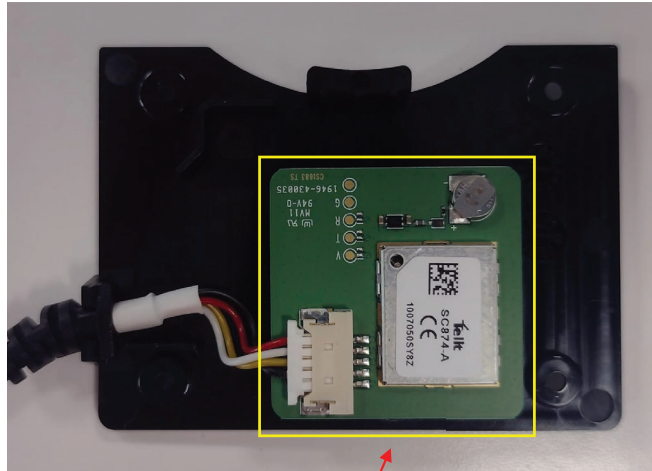
[15a] The antenna system comprises a third antenna (indicated in yellow)

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Claim 17

[17a] The wireless device of claim 15, wherein the third antenna is configured to provide operation in a second wireless service.



[17a] The third antenna (indicated in yellow) configured to provide operation in at least a second wireless service: GPS

GPS / GLONASS	Internal GPS / GLONASS
G-Sensor	Internal 3-axis G-sensor
Gyro	3 axis (X,Y,Z), output rate: 100 Hz
Alarm In / Out	2 x Alarm in 1 x Alarm out

Source: User Manual

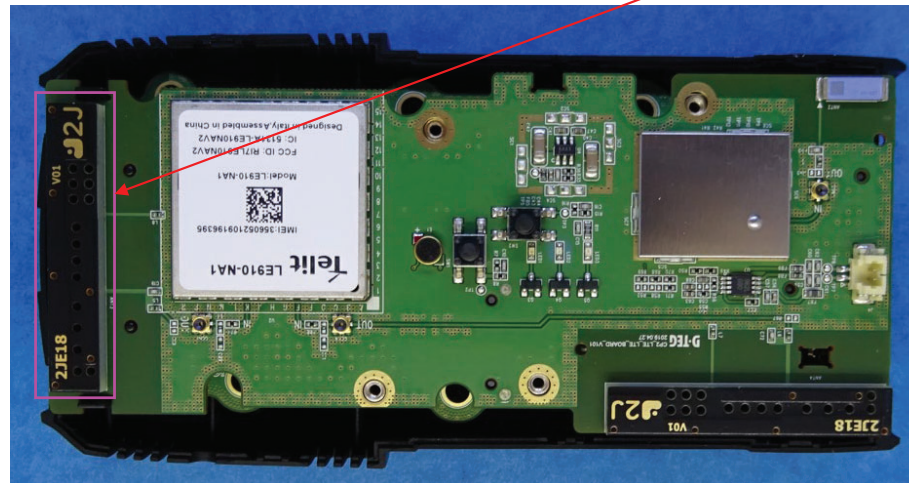
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Claim 19

[19a] The wireless device of claim 15, wherein the antenna system comprises a fourth antenna.

[19a] The antenna system comprises a fourth antenna (indicated in pink)



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