



**(43) International Publication Date**  
**27 December 2007 (27.12.2007)**

**(10) International Publication Number**  
**WO 2007/147629 A1**

**(51) International Patent Classification:**

**G06K 19/077 (2006.01)**

**(21) International Application Number:**

PCT/EP2007/005547

**(22) International Filing Date:** 22 June 2007 (22.06.2007)

(25) Filing Language: English

(26) **Publication Language:** English

**(30) Priority Data:**

06115954.7	23 June 2006 (23.06.2006)	EP
60/816,811	27 June 2006 (27.06.2006)	US

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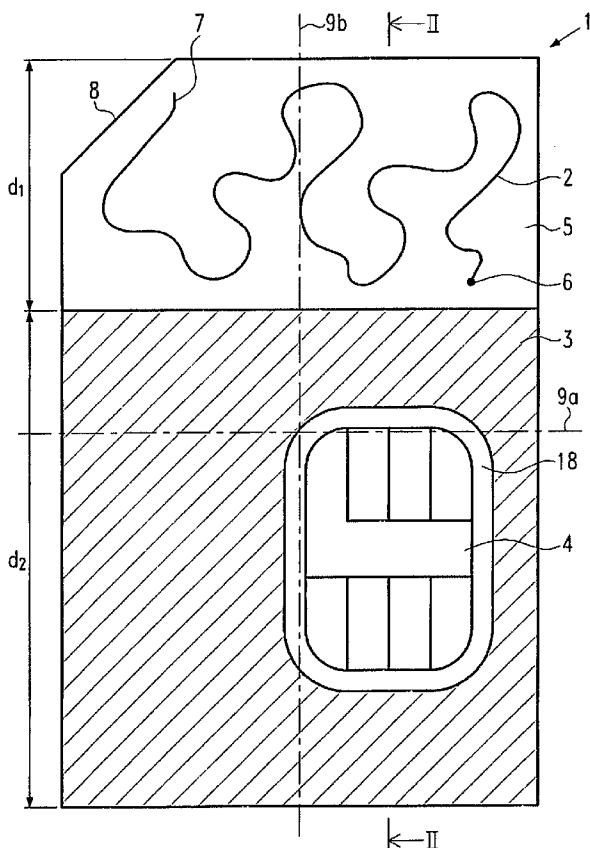
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**(81) Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

**(84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,

[Continued on next page]

**(54) Title:** CHIP MODULE, SIM CARD, WIRELESS DEVICE AND WIRELESS COMMUNICATION METHOD



**(57) Abstract:** The invention refers to a chip module comprising at least one memory and/or microprocessor chip and at least one antenna element connected to said chip. Further the invention relates to a SIM card comprising a dielectric substrate, eight or more contact pads provided on one side of said dielectric substrate, at least one memory and/or microprocessor chip provided on the other side of the substrate and connected to said contact pads, a first antenna element provided on the same side of the dielectric substrate as the chip, wherein the first antenna element has at least one driving point and at least one termination point, a second antenna element provided on the same side of the dielectric substrate as the first antenna element, wherein the first antenna element is given in an area different from the area where the contact pads are arranged, and the chip can be accessed by a wireless communication link with help of the antenna operating at a frequency of more than 800 MHz.



ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— with international search report

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## **Chip Module, SIM Card, Wireless Device and Wireless Communication Method**

The present invention relates to a chip module. Such a chip module may comprise a memory and/or a microprocessor chip.

A particular chip module is known from WO 2004/021271 A1. This chip module may be connected to an antenna which is provided in a device into which the module may be inserted.

The object of the present invention is to provide an improved chip module and an improved wireless device with the chip module, a SIM (subscriber identification module) card, a wireless device with a SIM card and a wireless communication method.

This problem is solved by the appended independent claims. Preferred embodiments are disclosed in the dependent claims.

The chip module of the present invention may e.g., comprise an antenna element, which preferably is connected to said chip.

The first antenna element is preferably connected to an RF-terminal of the chip.

This connection may be done e.g. by a wire bond, a coplanar transmission line, a slot line or a strip line.

With such an antenna element, it would be possible to connect to the memory or microprocessor in the chip module by a wireless communication system without the need of electrically contacting the chip in order to process or obtain data from the memory and/or microprocessor chip.

Nevertheless, the chip module may comprise contact means by which the chip may be connected directly through direct electric contact. Those contact means preferably comprise pads which are accessible from the outside of the chip module.

In a preferred embodiment, those contact means comprise at least 2, 4, 6, 8, 10, 12, 15 or more pads.

The antenna is preferably located in an area where there are no contact means or contact pads. Such contact pads are generally electrically conductive and may, therefore, absorb or alter the radiation of the antenna element. If the chip module is essentially rectangular (with or without a notch) the antenna element will be in the half of the chip module where there is not the major portion of the contact pads when considering the rectangular shape divided in two equal portions by a line extending parallel to the short edge of the rectangle.

Preferably, in a view perpendicular to the chip module plane, the contact means or contact pads do not overlap the antenna element. The same preferably applies to a second antenna element which will be discussed below.

The antenna element in a preferred embodiment has a conductive pattern. This pattern is provided in 1, 2, 3 or more planes, while multiple of those planes are preferably parallel to each other.

The at least one antenna element preferably has a driving point (feeding point) and at least or exactly 1, 2, 3 or more termination points. In some embodiments, the at least one antenna element includes 1, 2, 3 or more connections to a radio frequency (RF) ground. In case of more than one termination point, the antenna element will be a multiple branch antenna. Except for the feeding point in some embodiments, the first antenna element may be separated from the second antenna element (see below) by a minimum distance of at least 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 mm and/or not more than 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 mm. Preferred is a distance between 1 and 3 mm.

Further the driving point preferably is separated from the chip module edge by at least 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 mm and/or not more than 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 mm.

The driving point is preferably located not further away from a feeding terminal of the chip than 1, 2, 3, 4, 5, 7, 10, 12, 15, 20, 25, 30, 40, 50 percent of largest extension of the chip module.

If the chip module is essentially rectangular (with or without a notch) the driving point may be provided in the half where there is the major portion of the contact pads when considering the rectangular shape divided in two equal portions by a line extending parallel to the long edge of the rectangle.

Any termination point may be open ended, which means that this end is not electrically connected to any other item. Any termination end may also be connected to the chip or to a second antenna element (see below).

If the chip module is essentially rectangular (with or without notch) the chip module has four areas separated by two straight lines crossing in the middle of the rectangle one being parallel to the short edge and the other being parallel to the long edge of the rectangle. One of those four areas contains the major portion of the contact pad area. A termination point or two or three or more or all termination points may be provided in the area which is the diagonally opposite area to that of the contact pads.

The chip module preferably comprises a dielectric substrate. It may, however, comprise 2, 3 or more dielectric substrates and/or a multilayer substrate in order to provide different layers in which conductive elements may be provided.

The antenna element may be provided entirely on one and the same plane. Further, the antenna element may be provided in the same plane or on the same surface of a dielectric substrate as the contact means or the contact pads. The

antenna element may, however, also be provided on a different plane or surface or different planes or surfaces.

The first and/or second antenna element may be provided on the same surface of a dielectric substrate as the chip(s) or on different surfaces.

The chip module is preferably compliant with the ISO 7816 standard.

In particular, the chip module is preferably a SIM card, such as e.g. for a wireless phone or handheld wireless device or a multifunctional wireless device.

As mentioned above, the chip module may comprise 1, 2, 3 or more chips. One chip may be e.g., a memory. Further, the chip module may comprise a microprocessor and/or it may comprise a radio frequency chip which is suitable for generating and/or receiving radio frequency signals which can then be fed to the antenna element or antenna elements.

The chip module may additionally comprise a second antenna element (as mentioned above). The second antenna element may be a ground plane or a ground counterpoise. It may also be a second antenna element of the dipole antenna such as a second antenna arm, where the other (first) arm is given by the first antenna element.

The second antenna element is preferably connected to the chip, in particular, to an RF terminal of the chip and/or a ground terminal.

In a view onto the chip module in which the chip module appears with the largest size, the second antenna element may cover a certain percentage of the chip module size such as e.g., more than 10, 20, 30, 40, 50, 60, 70, 80, 85 or 90 percent or it may cover less than 20, 30, 40, 50, 60, 70, 80, 85, 90 or 95 percent. In a plane where there are no other conductive elements it may also cover 100% of the size. In this case the first antenna element will be provided below or above this second antenna element.

The second antenna element has 1, 2, 3 or more clearances. A clearance in the second antenna element is an area in the plane of the second antenna element where there is no portion of the second antenna element. Such a clearance may be used for e.g., locating the first antenna element or for locating contact means/pads. Further, the clearance may be used to locate a chip that extends in or into the plane of the second antenna element.

The clearance which accommodates the first antenna element will preferably be provided next to a notch of the chip module.

The area covered by the clearance in which the first antenna element is provided may be more or less than a percentage of 10, 20, 30, 40, 50, 60, 70, 80, or 90 percent of the area covered by the second antenna element. Typically the area of the clearance may be between 40 and 70 percent of the area of the second antenna element.

The clearance in which the contact pads are provided can be made such that it surrounds and encloses the contact pads (in a view perpendicular onto the chip module).

The first antenna element and/or the second antenna element may comprise at least 4, 5, 6, 7, 8, 9, 10, 12, 15, 17, 20, 25 or 30 segments. A segment may be straight or curved.

It is preferred that right and left curved segments are provided (when following the curve) and/or that at connection points of a straight segment angles to the left and to the right (when following the curve) are provided. Preferably the number of left and right curved segments (if provided) does not differ by more than 80, 70, 60, 50, 40, 30, 20 or 10% of the larger of the two numbers. Also the number of connection angles between adjacent segments which following the curve go to the right and those that go to the left do not differ by more than 80, 70, 60, 50, 40, 30,

20 or 10% of the larger of the two numbers. Further preferably the number of the left curved segments plus the number of the connections points where the curve turns left and the number of the right curved segments plus the number of connection points where the curve turns right do not differ by more than 80, 70, 60, 50, 40, 30, 20 or 10% of the larger of the two numbers. With those measures it is possible to reduce the inductance of the curve, which would be given when e.g. coiling a curve by all angles or almost all (all but one, two or three) angles and/or curved segments turning to the same direction.

Furthermore, the first and/or second antenna element may be shaped according to a space filling curve, a box counting curve, a grid dimension curve or a multilevel structure as defined below.

The first and second antenna element may be provided in the same plane or on the same surface of a dielectric substrate or on different planes or surfaces.

The chip module preferably has an essentially rectangular outer shape with a notch in one corner in order to identify the orientation of the chip module and hence the location of contact pads, if present. It may e.g. have a length of 25 mm and/or a width of 10 mm.

The first antenna element has a termination point which is preferably closer to a chip module border than to the second antenna element. The termination point is preferably close to or at a chip module border which does not limit the first antenna element.

The first antenna element may further be a slot.

The first antenna element may be a monopole. As mentioned above, the first antenna element may also be a dipole or part of a dipole.

The second antenna element may be connected to a contact pad that is used for grounding purposes. A ground plane may, however, not be connected to any



contact pad. The latter is in particular advantageous in case of a dipole, loop or folded dipole antenna, where the ground plane may be floating.

Furthermore, between the chip and the first and/or second antenna element, a passive network or an active network may be provided. The network may be a matching network, a filter or a balun network.

The chip module may be adapted for wireless operation in a range of up to 3 to 5 m.

Further the chip module is adapted for operation in the far field, which in practical purposes means, that data transmission via the wireless connection is carried out between devices which are separated by more than a half-wavelength.

Typical operation frequencies are above 800 MHz such as 868 MHz, 915 MHz or 2.4 GHz or any other ISM (Industry, Science, Medicine) band.

The chip module preferably has a (largest) thickness of less than 1.5, 1.2, 1.0, 0.9, 0.8, 0.7, 0.6 or 0.5 mm and/or a thickness of more than 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, or 1.5 mm. Particularly preferred is a value of  $0.8 \pm 0.05$  mm.

A wireless device comprises a chip module as explained above or further below.

The wireless device may e.g. be a cellular phone or another multifunctional wireless device such as e.g. a PDA.

In such a wireless device, the first and/or second antenna element is preferably separated from the ground of the wireless device and/or from the battery of the wireless device by more than 0.5, 0.7, 1.0, 1.2 or 1.5 mm and/or less than 5, 4, 3, 2 or 1 mm.

The ground of the chip module is preferably connected to the ground of the wireless device. This connection may be ohmic or capacitive or inductive. Preferred is a direct ohmic contact.

The wireless device may comprise a battery. Such a battery may have a ground contact with which it will be connected to the ground of the wireless device. Further the wireless device may comprise a display (e.g. LCD), a digital connector, a power supply connector and/or an antenna of a mobile telephone system. The chip module is preferably separated from the

- ground contact of the battery and/or
- the ground contact of the display and/or
- the ground contact of the digital connector or power supply connector and/or
- a grounded element or ground contact of the mobile telephone system antenna and/or
- a mobile telephone system antenna itself and/or
- a Bluetooth/WIFI antenna

by at least 20, 30, 40, 50, 60, 70 or 80 percent of the largest extension of the wireless device.

The wireless device may have a chip module holder. This chip module holder preferably is made of or comprises plastic or dielectric materials. It is preferred that no metallic or conductive materials are provided in the holder.

The chip module is preferably arranged in such an orientation that the first antenna element shows to the periphery while the second antenna element shows towards the interior of the wireless device, when the chip module is substantially parallel to the ground plane of the wireless device.

The chip module may be contacted by another device, which reads out information from the chip of the chip module. With this information the device may perform actions which are only possible with the data of the chip module, without, however, this device actually having the chip module incorporated. The performed actions may be financial transactions or telephone calls, or the like. In this way e.g. a

wireless phone system of a car may contact the chip module and thereby perform a telephone call with the identification data of the chip module. Equally a computer may access the identification data and perform internet actions, financial transactions or the like. Another possibility is for instance to execute a remote payment transaction with a mobile phone or handheld device without necessarily connecting to a mobile or cellular network, but directly to a payment unit placed at a short distance (typically below 30, 20 or 10 m) of the mobile phone, handheld device or multifunctional wireless device.

The chip module preferably is removable from the wireless device. The wireless device is constructed such that the chip module is exchangeable (without destroying the wireless device).

In the following some preferred embodiments of the invention will be described with reference to the enclosed figures. They are provided only for explaining some preferred embodiments of the invention without however limiting the scope of the invention. Here it is shown in:

Fig. 1            a schematic view onto a chip module according to the invention,

Fig. 2            a schematic view on the cut between II – II as shown in Fig. 1,

Fig. 3            a schematic view onto the chip module onto the opposite side in comparison to Fig. 1,

Fig. 4            possible shapes of the first and/or second antenna element,

Fig. 5            a schematic view of a preferred embodiment of the chip module,

Fig. 6            a schematic view of a possible configuration of the second antenna element,

Fig. 7            a schematic view of a preferred embodiment of the chip module,

- Fig. 8            a schematic view of a wireless device,
- Fig. 9            a schematic view of a section of the wireless device of Fig. 8,
- Fig. 10           a schematic view onto a chip module according to a preferred embodiment,
- Fig. 11           a schematic view onto a chip module according to another preferred embodiment,
- Fig. 12           a schematic view onto a chip module according to a further preferred embodiment,
- Fig. 13           a schematic view on a particular embodiment of the invention,
- Fig. 14           a schematic view on a SMART card with a chip module,
- Fig. 15           example of a box counting curve located in a first grid of 5x5 boxes and in a second grid of 10x10 boxes,
- Fig. 16           example of a grid dimension curve,
- Fig. 17           example of a grid dimension curve located in a first grid,
- Fig. 18           example of a grid dimension curve located in a second grid,
- Fig. 19           example of a grid dimension curve located in a third grid.

In Fig. 1, a chip module 1 is shown. The chip module operates preferably in the 2.4 GHz ISM band, preferably using a ZigBee connectivity standard. This chip module 1 has a first antenna element 2 that is shaped as a trace. This trace is

shown for explanatory purposes only. The shown trace does not necessarily operate at the desired frequency, since this may further depend on the materials involved such as the dielectric constant of the substrate material. This first antenna element 2 has a feeding point 6 and a termination point 7. This first antenna element 2 is provided in a clearance 5 of the second antenna element 3. This means that in the view (perpendicular onto the chip module plane) shown in Fig. 1, the first and the second antenna elements 2, 3 do not overlap.

Furthermore, a contact area 4 is shown. This contact area 4 has different contact pads as shown. Those contact pads are provided in a clearance 18 of the second antenna element 3.

The chip module essentially has a rectangular shape with a notch 8 in one corner (upper left in Fig. 1). The clearance 5 is located next to the notch 8.

The clearance 5 of the second antenna element 3 occupies a certain portion of the chip module as can be seen in Fig. 1. This clearance portion is smaller than the area covered by the second antenna element 3.

A line 9a is shown which is parallel to the short edge and dividing the rectangle in two equal areas (above and below line 9a). The line 9a is provided at a distance  $(d1+d2)/2$  from the short edge of the rectangle. The line 9b is parallel to the long edge and divides the rectangle in two equal areas (left and right of line 9b). The two lines 9a and 9b cross in the middle of the rectangle. The major portion of the contact area 4 is provided in the lower right area of the four areas divided by lines 9a and 9b and the termination point 7 is provided, preferably, in the diagonally opposite area of the four areas. In other embodiments it is possible to place the one or more termination points in any of the four areas.

In Fig. 1, a particular case is shown where the clearance 5 has an extension in the length direction of the chip module (vertical direction in Fig. 1, along the long edge of the chip module) of  $d1$  and the second antenna element 3 has an extension of  $d2$ .  $d1$  may be e.g. more than 5, 6, 7, 8, 9, 10, 12, 15, 17, 20, 25 mm or may be

less than any of those values. Additionally, the measure  $d_2$  may be more than 5, 7, 10, 12, 15, 20 mm or may be less than any of those values.  $d_1$  may be less than  $d_2$ , as e.g. shown in Fig. 1.

As can be seen in Fig. 1 if the measure of  $d_1+d_2$  is assumed to be 25 mm then the distance between the driving point 6 and the second antenna element 3 is approximately 1 mm or less. In the horizontal direction the driving point 6 is provided on the side of the chip module (right the line 9b) where the major portion of the contact pads area 4 is provided. Further it is separated by a few mm from the right edge.

In some chip modules with  $d_1+d_2$  other than 25 mm, all the dimensions in the preferred embodiments may be scaled proportionally. In some chip modules with frequency operation other than 2.4 GHz, all the dimensions in the preferred embodiments may be scaled proportionally to the frequency.

In the length direction of the rectangular chip module the first antenna element 2 is provided in the opposite half (upper half above line 9a) in comparison to the half (lower half below line 9b) where the major portion of the contact pad areas is provided.

The longest extension of the chip module 1 in Fig. 1 is the diagonal line extending from the lower left corner to the upper right corner.

In Fig. 2, a cut along a section line II-II as shown in Fig. 1 is shown. On the dielectric substrate 10, contact pads in the area 4 are shown. In Fig. 2, the contacts preside over the bottom surface of the substrate 10. They may, however, also be plane with the surface of substrate 10. In this case, the contact pads in area 4 are embedded in the substrate 10.

The substrate 10 may be provided with via holes or other contact/interconnection means 14 with which it is possible to connect the contact pads in area 4 with the

chip 12. Also wire bonds 13 may be used to contact the chip 12 with the contacts in area 4.

In Fig. 2, the ground plane 3 can be seen to be on two sides of the chip 12, since the chip 12 is provided in a clearance of the second antenna element 3. The first antenna element 2 is provided in the clearance 5 of the second antenna element 3.

On the right hand side, cuts to the trace 2 are shown. As can be seen the first antenna element 2 and the second antenna element 3 are provided in the same plane and at the same time on the same surface of a dielectric substrate 10. Other substrates may be provided which will preferably be made parallel to the substrate 10 in order to have further planes or surfaces available to accommodate the first and/or second antenna element or at least a portion thereof. Also a multilayer substrate may be used for this purpose.

As can be seen in Fig. 2 the first and second antenna elements 2, 3 are provided on the same surface of the dielectric substrate 10 as the chip 12.

In Fig. 2 only one chip 12 is shown. Two, three or more chips may, however, be provided.

The chip 12, the connections 13, 14 and the first and second antenna element 2, 3 are embedded in a second dielectric layer 11 which gives the module its outer shape, supports the different components in their position and isolates them against each other.

The substrate 10 and the dielectric layer 11 are omitted in the views of Fig. 1, 3, 5, 7, 10, 11 or 12.

In Fig. 3 the chip module of Fig. 1 is shown from the opposite side (see notch 8). Here the chip 12 can be seen. The chip 12 is connected with wire bonds 13 to a contact point 15. Metallizations 16 extend from each contact point 15 to e.g. a via

hole or the like. One metallization extends to another contact point which is connected with a wire bond 17 to the driving point 6 of the first antenna element 2. The second antenna element 3 may also be connected to the chip 12 by a wire bond which directly connects from the chip 12 to the second antenna element 3. An additional metallization and/or wire bond may be provided for such a connection. The metallizations are provided in the same plane and on the same surface as the first and/or second antenna elements 2, 3.

The chip 12 and the metallizations 16 can be seen to be provided in the clearance 18 of the second antenna element 3.

In Fig. 3 a further feature is shown which may be provided in any of the other shown embodiments and which in any case is optional (also in Fig. 3). The first antenna element 2 may be provided with an electrical connection (preferably direct electrical connection) to the second antenna element 3. In this way it is, for example, possible to achieve an inverted-F antenna (IFA). Further by such connections particular resonant modes of the antenna may be suppressed or supported. Such a connection may be given by a trace or a wire bond or the like.

In Fig. 4A, a case is shown where the first antenna element 2a has a trace which is composed of straight segments. Here, the straight segments are all perpendicular to each other. However, smaller than 90° angle or larger than 90° angle may be provided between different segments, such as angles between 30° and 90° and/or angles between 90° and 180°.

At a point where two straight segments connect to each other, they do not have an angle of 180° (flat angle) but different from 180°.

In Fig. 4B, a case is shown where the trace is composed of curved segments. The segments can be identified by a different curvature. With the dotted lines, the separation points between the different segments are indicated. In those points, the curvature changes from a right hand curve to a left hand curve or vice versa.



In Fig. 4C, a case is shown where the trace is composed of curved and straight segments. The straight segments are provided between curved segments. It may also be possible that two straight segments are connected with each other without a curved segment in between, in which case the two straight segments will have an angle at their connection point being different from  $180^\circ$  (see left end of the curve 2c, last two segments). In such a connection point no unique tangent or curvature is given. Such points can be used for identifying the end or ends of a particular segment. Also there may be an angle different from  $180^\circ$  between a curved and a straight segment (see connection between second and third segment and between third and fourth segment when starting from the left end of Fig. 4c). The angle at a connection point between a straight and a curved segment may nevertheless be  $180^\circ$  (see Fig. 4c).

In Fig. 4C, curved segments are identified by a different curvature (curved to the left or curved to the right).

When starting from the left end of Fig. 4c at the first connection point the curve turns to the right and at the second to the left and then again to the right.

In Fig. 4 the trace thickness (line thickness) is constant along the trace. In general 1, 2, 3 or more or all segments may have the same thickness. The thickness of the trace may, nevertheless, vary along the trace or along 1, 2, 3 or more or all segments. E.g. 1, 2, 3, or more segments may be tapered. The thickness may further change in a stepwise fashion at 1, 2, 3 or more connection points of two neighboring segments or within 1, 2, 3 or more segments.

The shapes shown in Figs. 4a to 4c may also be given by the shapes of the second antenna element 3 or at least by a portion of the second antenna element 3.

A curve composed of straight or curved segments (such as those discussed in relation to Fig. 4) may be the centerline of the conductive trace or may be one border line of the conductive trace.

In Fig. 5, a preferred embodiment of a chip module 1 is shown where the first antenna element 2 is separated from the second antenna element 3 by a gap of size  $g$ . A feeding point 6 is outside of the gap. As indicated with the alternative feeding point 6', at least the feeding point 6' and the connection from the feeding point 6' to the antenna element 2 may be given in the gap. Once the trace left the area of the gap, it, however, never returns back into the area of the gap.

The gap surrounds the border of the second antenna element 3. The gap has a width which may be more than 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20 percent of the largest extension of the chip module 1.

As can be seen in Fig. 1 and Fig. 5, the feeding terminal 6 is preferably close to the contact area 4, or at least close to the chip 12. This simplifies contacting the chip with the feeding point. This connection may be performed, e.g., by a wire bond or a conductor.

In Fig. 6, a preferred embodiment of the second antenna element 3 is shown. This antenna element 3 has a portion 20 which is given by at least four segments here in particular by 9 segments. The segments may be straight or curved, as explained in connection with Fig. 4.

This portion 20 may also be shaped according to a space filling curve, a box counting curve, a grid dimension curve or a multilevel structure. The entire second antenna element 3 may be shaped according to a space filling curve, a box counting curve, a grid dimension curve or a multilevel structure.

Fig. 7 shows another preferred embodiment of the chip module 1. Here the first antenna element 2 is indicated by a thick line. The second antenna element 3 may comprise a parasitic element 22 which is directly electrically connected with the second antenna element 3. This parasitic element 22 may be provided in a plane parallel to that of the first antenna element 2. At the points where the two lines 2 and 22 in Fig. 7 cross, there is no electric connection since at the crossings, the

two patterns are isolated against each other. This may be e.g., given by an isolation film or a dielectric substrate or substrate layer between the two conductive patterns of lines 2 and 22.

The entire parasitic element 22 or at least a portion thereof may also be shaped according to a space filling curve, a box counting curve, a grid dimension curve or a multilevel structure.

The parasitic element 22 starts at the right side and somehow follows the first antenna element 2 to the left. The opposite may be the case, namely that the parasitic element 22 is connected to the second antenna element 3 on the left side and then follows the first antenna element 2 to the right side. In general, the connection point of the parasitic element 22 to the second antenna element 3 may be closer to the termination point 7 of the first antenna element than to the drive point 6. The termination of the parasitic element 22 (if provided) is preferably closer to drive point 6 than to the termination point 7.

In Fig. 8, an example of a wireless device 25 is shown. This wireless device 25 may comprise an antenna 27 such as e.g., the antenna of a mobile telephone system. The antenna 27 is shown schematically only. This antenna 27 is not connected to chip module 1. Further a Bluetooth or WIFI antenna 28 may be provided.

The wireless device 25 also comprises a battery 26. This battery 26 has a grounding terminal 29 connected to ground 30 as can be seen in Fig. 8. The battery is used as a power source for the mobile telephone and optionally also for the chip module 1.

The wireless device 25 also comprises a chip module 1. This chip module 1 may be also connected to ground 30 as shown in Fig. 8. The chip module 1 may be held in a module holder (not shown).

The chip module 1 in Fig. 8 is partially overlapping the battery 26 and partially not overlapping the battery 26. It may also entirely overlap the battery 26 or not overlap the battery 26 at all. The first or the later are preferred but not always possible, depending on the size of the chip module 1, of the battery 26 and of the device 25.

Further, the chip module 1 is separated from the edge of the wireless device 25 in one direction by a distance  $S1$ , and in another (perpendicular) direction by a distance  $S2$ .  $S2$  may be less than 40, 30, 25, 20, 15, 12, 10, 8, 7 or 5 percent of the largest extension of the wireless device 25 or more than one of those values. The same applies to the separation  $S1$ . Usually the smallest separation from an edge (here  $S1$ ) will be considered to be less than 40, 30, 25, 20, 15, 12, 10, 8, 7 or 5 percent of the largest extension of the wireless device 25 and/or more than one of those values. In some embodiments the smaller the smallest separation the better for antenna performance.

The largest extension of the wireless device 25 in Fig. 8 is given by the diagonal from the lower right up to the upper left corner.

In Fig. 8 the first antenna element is in the upper portion of the chip module 1 and the second antenna element is arranged in the lower portion. With the location below the middle of the wireless device the upper portion shows towards the interior of the wireless device while the lower portion shows towards the periphery. The opposite orientation may be preferred for reasons of the antenna performance.

Fig. 9 shows a section of the wireless device 25 of Fig. 8. The chip module 1 is provided in the upper portion of Fig. 9. In the lower portion, a ground plane 35 of the wireless device 25 is shown. As can be seen in Fig. 9, the second conductive element 3 is connected to one of the contact pads 36 e.g. by a via hole or analogous connecting means 37. This contact pad 36 is used for grounding purposes. It may also be used for grounding a portion of the chip 12. As can be schematically seen in Fig. 9, this grounding terminal 36 or grounding pad 36 is

connected to ground 35 of the wireless device. This connection is releasable. This means that the chip module 1 is removable from the wireless device 25.

The second antenna element 3 may also not be connected to the ground plane 35 of the wireless device 25.

A power line (not shown) may be provided from the wireless device 25 to the chip module 1.

In Fig. 10 another preferred embodiment is shown in a view such as in Fig. 3. In this view the second antenna element 3 does not completely enclose the chip 12 or the clearance 18 since a gap or slot 51 is provided. This gap or slot 51 gives room for a feed line 50 which connects the chip 12 with the driving point 6 of the first antenna element 2. This feed line 50 may be connected to the chip 12 with a wire bond. The chip is provided with a RF-terminal RF1. Another RF terminal RF2 is provided for connecting the chip 12 to the second antenna element 3, which is designed as a ground plane here. This connection might be done at the right side, at the left side or at both sides of the feed line 50. A co-planar feed line is shown in this particular case, but a microstrip line, a strip-line, a slot line, a coplanar strip line or the like is possible within the scope of the invention.

In Fig. 11 the case is shown where the first antenna element 3 is given by a slot 60. This slot may be composed of at least 4, 5, 6, 8, 10, 12, 15, 20, 15 or more segments (straight or curved, see explanations of Fig. 4).

The slot antenna is given by a slot 60 in the ground plane (second antenna element). From the chip 12 two RF connections 63, 64 are provided to opposite sides of the feed slot 62 for balanced or unbalanced feeding. Other feeding means than a feeding slot 62 may be given to feed the slot 60, such as e.g. a microstrip line, a strip-line, a slot line, a coplanar strip line or the like. Ground plane element 3 may be connected to a ground layer of the wireless device as for instance in Fig. 9. The slot 60 is open ended at one end 61, where the slot 60 leaves the

border of the second antenna element 3. This end 61 can be provided at an edge of the chip module 1, as shown in Fig. 11.

A further slot may be formed in the second antenna element 3. This slot may start at the clearance 18. If the first slot 60, 62 also starts from the clearance 18, then a combined slot is given. This second slot preferably is closed at the end opposite to the end of the clearance 18, which means, that the slot terminates within the second antenna element 3. It may, nevertheless, also be open ended. More than two, or three slots may be provided at the clearance 18.

In Fig. 12 a schematic view onto the chip module 1 is shown in which no second antenna element is provided. The first antenna element 2 can be shaped such that it covers the major portion of the chip module 1. A drive point 6 is provided close to the pad area 4. In the pad area 4 a RF terminal 76 is given which is connected to the drive point 6 by a wire bond 70 and a metallization which ends at point 71.

Further it is shown, that the first antenna element 2 may be connected to a ground pad 72 by a wire bond 74 which connects the contact point 73 of the first antenna element 2 with the contact point 75 of a metallization which is connected to the ground pad 72. This connection of the first antenna element 2 with the ground pad 75 is optional.

The wire bonds are shown in dotted line since they will be provided on the other side of the chip module than that shown in Fig. 12.

Fig.13 shows a preferred embodiment of the invention. A SIM card 1305 comprises a first antenna element 1301 including a feeding point 1302, and second antenna element 1303. Both antenna elements 1301 and 1303 are lying on the same layer of a dielectric substrate 1304. Second antenna element 1303 may further include a clearance (not shown) to host contact pads of the SIM card. Also, second antenna element 1303 may further include a connection to a ground pad of the SIM card, therefore becoming a ground element for the antenna system. In the later case, second antenna element becomes connected to the

ground of the wireless device and element 1301 extends out of the ground in a monopole arrangement. A particular design of SFC curve is shown in element 1301, which fits in a substantially rectangular area that extends orthogonally from the ground element 1303. Other SFC or grid-dimension curves with other number of segments as described in the present invention are possible as well. Other form factors rather than a rectangular area (such as for instance an 'L', 'C', 'S', 'G', 'M', 'N' or 'U' area shape, to name a few examples) could be used to enclose the SFC or grid-dimension curves in element 1301.

Fig. 14 shows a SMART card 40 which accommodates a chip module or SIM card 1.

#### Space Filling Curves

In some examples, at least the first and/or the second antenna element may be miniaturized by shaping at least a portion of the conducting trace, conducting wire or contour of a conducting sheet of the antenna element (e.g., a portion of the arm(s) of a monopole/dipole, of the perimeter of the patch of a patch antenna, of the slot in a slot antenna, of the loop perimeter in a loop antenna, or other portions of the antenna) as a space-filling curve (SFC).

A SFC is a curve that is large in terms of physical length but small in terms of the area in which the curve can be included. More precisely, for the purposes of this patent document, a SFC is defined as follows: a curve having at least five segments (straight or curved, see explanations concerning Fig. 4)), that are connected in such a way that no pair of adjacent segments define a larger straight segment. In addition, a SFC does not intersect with itself at any point except possibly the initial and final point (that is, the whole curve can be arranged as a closed curve or loop, but none of the lesser parts of the curve form a closed curve or loop).

A space-filling curve can be fitted over a flat or curved surface, and due to the angles between straight and straight, straight and curved segments or curved and curved segments or due to the curved segments, the physical length of the curve is larger than that of any straight line that can be fitted in the same area (surface) as the

space-filling curve. Additionally, to shape the structure of a miniature antenna, the segments of the SFCs should be shorter than at least one fifth of the free-space operating wavelength, and possibly shorter than one tenth of the free-space operating wavelength. The space-filling curve should include at least five segments in order to provide some antenna size reduction, however a larger number of segments may be used, such as at least 8, 10, 15, 20, 25 or 30 or more segments. In general, the larger the number of segments, and the narrower the angles between them or the stronger the curvature, the smaller the size of the final antenna.

### Box-Counting Curves

In other examples, at least the first and/or the second antenna element may be miniaturized by shaping at least a portion of the conducting trace, conducting wire, a slot or contour of a conducting sheet of the antenna to have a selected box-counting dimension. Also a portion of a slot in a ground plane may be shaped as a box-counting curve.

For a given geometry lying on a surface, the box-counting dimension is computed as follows. First, a grid with substantially squared identical cells boxes of size  $L1$  is placed over the geometry, such that the grid completely covers the geometry, that is, no part of the curve is out of the grid. The number of boxes  $N1$  that include at least a point of the geometry are then counted. Second, a grid with boxes of size  $L2$  ( $L2$  being smaller than  $L1$ ) is also placed over the geometry, such that the grid completely covers the geometry, and the number of boxes  $N2$  that include at least a point of the geometry are counted. The box-counting dimension  $D$  is then computed as:

$$D = -\frac{\log(N2) - \log(N1)}{\log(L2) - \log(L1)}$$

For the purposes of the first and/or the second antenna element described herein, the box-counting dimension may be computed by placing the first and second grids



inside a minimum rectangular area enclosing the conducting trace, conducting wire or contour of a conducting sheet of the antenna and applying the above algorithm.

The first grid should be chosen such that the rectangular area is meshed in an array of at least 5 x 5 boxes or cells, and the second grid should be chosen such that  $L_2 = 1/2 L$  and such that the second grid includes at least 10 x 10 boxes. The minimum rectangular area is an area in which there is not an entire row or column on the perimeter of the grid that does not contain any piece of the curve.

The desired box-counting dimension for the curve may be selected to achieve a desired amount of miniaturization. The box-counting dimension should be larger than 1.1 in order to achieve some antenna size reduction. Preferably it will be larger than 1.2, 1.25, 1.3 or 1.35. If a larger degree of miniaturization is desired, then a larger box-counting dimension may be selected, such as a box-counting dimension ranging from 1.5 to 2. For the purposes of this patent document, curves in which at least a portion of the geometry of the curve has a box-counting dimension larger than 1.1 are referred to as box-counting curves.

For very small antennas, for example antennas that fit within a rectangle having maximum size equal to one-twentieth the longest free-space operating wavelength of the antenna, the box-counting dimension may be computed using a finer grid. In such a case, the first grid may include a mesh of 10 x 10 equal cells, and the second grid may include a mesh of 20 x 20 equal cells. The box-counting dimension (D) may then be calculated using the above equation.

In general, for a given resonant frequency of the antenna, the larger the box-counting dimension, the higher the degree of miniaturization that will be achieved by the antenna. One way to enhance the miniaturization capabilities of the antenna is to arrange the several segments of the curve of the antenna pattern in such a way that the curve intersects at least one point of at least 14 boxes of the first grid with 5 x 5 boxes or cells enclosing the curve. If a higher degree of miniaturization is desired, then the curve may be arranged to cross at least one of the boxes twice within the 5

x 5 grid, that is, the curve may include two non-adjacent portions inside at least one of the cells or boxes of the grid.

Fig. 15 illustrates an example of how the box-counting dimension of a curve 1200 is calculated. The example curve 1200 is placed under a 5 x 5 grid 1201 and under a 10 x 10 grid 1202. As illustrated, the curve 1200 touches  $N_1=25$  boxes in the 5 x 5 grid 1201 and touches  $N_2=78$  boxes in the 10 x 10 grid 1202. In this case, the size of the boxes in the 5 x 5 grid 1201 is twice the size of the boxes in the 10 x 10 grid 1202. By applying the above equation, the box-counting dimension of the example curve 1200 may be calculated as  $D=1.6415$ . In addition, further miniaturization is achieved in this example because the curve 1200 crosses more than 14 of the 25 boxes in grid 1201, and also crosses at least one box twice, that is, at least one box contains two non-adjacent segments of the curve. More specifically, the curve 1200 in the illustrated example crosses twice in 13 boxes out of the 25 boxes.

#### Grid Dimension Curves

In further examples, at least the first and/or the second antenna element may be miniaturized by shaping at least a portion of the conducting trace, conducting wire, a slot or contour of a conducting sheet of the antenna to include a grid dimension curve.

Also a portion of a slot in a ground plane may be shaped as a box-counting curve.

For a given geometry lying on a planar or curved surface, the grid dimension of curve may be calculated as follows. First, a grid with substantially identical cells of size  $L_1$  is placed over the geometry of the curve, such that the grid completely covers the geometry, and the number of cells  $N_1$  that include at least a point of the geometry are counted. Second, a grid with cells of size  $L_2$  ( $L_2$  being smaller than  $L_1$ ) is also placed over the geometry, such that the grid completely covers the geometry, and the number of cells  $N_2$  that include at least a point of the geometry are counted again. The grid dimension  $D$  is then computed as:

$$D = -\frac{\log(N2) - \log(N1)}{\log(L2) - \log(L1)}$$

For the purposes of the first and/or the second antenna element described herein, the grid dimension may be calculated by placing the first and second grids inside the minimum rectangular area enclosing the curve of the antenna and applying the above algorithm.

The minimum rectangular area is an area in which there is not an entire row or column on the perimeter of the grid that does not contain any piece of the curve.

The first grid may, for example, be chosen such that the rectangular area is meshed in an array of at least 25 substantially equal cells. The second grid may, for example, be chosen such that each cell of the first grid is divided in 4 equal cells, such that the size of the new cells is  $L2 = \frac{1}{2} L1$ , and the second grid includes at least 100 cells.

The desired grid dimension for the curve may be selected to achieve a desired amount of miniaturization. The grid dimension should be larger than 1.15 in order to achieve some antenna size reduction. If a larger degree of miniaturization is desired, then a larger grid dimension may be selected, such as a grid dimension ranging from 1.5 - 2. In some examples, a curve having a grid dimension of about 2 may be desired. For the purposes of this patent document, a curve having a grid dimension larger than 1.15 is referred to as a grid dimension curve.

In general, for a given resonant frequency of the antenna, the larger the grid dimension the higher the degree of miniaturization that will be achieved by the antenna. One example way of enhancing the miniaturization capabilities of the antenna is to arrange the several segments of the curve of the antenna pattern in such a way that the curve intersects at least one point of at least 50% of the cells of the first grid with at least 25 cells enclosing the curve. In another example, a high degree of miniaturization may be achieved by arranging the antenna such that the curve crosses at least one of the cells twice within the 25-cell grid, that is, the curve includes two non-adjacent portions inside at least one of the cells or cells of the grid.

An example of a grid dimension curve 1300 is shown in Fig. 16. The grid dimension curve of Fig. 16 placed in a first grid 1400 is shown in Fig. 17. The same curve in a second grid 1500 is shown in Fig. 18 and in a third grid 1600 in Fig. 19.

### Multilevel Structures

In some examples, at least a portion or the entire first and/or second antenna element may be coupled, either through direct contact or electromagnetic coupling, to a conducting surface, such as a conducting polygonal or multilevel structure. Further at least a portion or the entire first and/or second antenna element may be given the geometry of a polygonal or multilevel structure.

Also the slot or a portion of a slot may be shaped as a polygonal or multilevel structure.

A multilevel structure is formed by gathering several geometric elements such as for instance polygons or polyhedrons of the same type (e.g., triangles, parallelepipeds, pentagons, hexagons, circles or ellipses as special limiting cases of a polygon with a large number of sides, as well as tetrahedral, hexahedra, prisms, dodecahedra, etc.) and coupling these structures to each other electromagnetically, whether by proximity or by direct contact between elements such that the majority of said geometric elements are generally identifiable as either overlapping or non overlapping elements within said structure. The majority of the component elements of a multilevel have more than 50% of their perimeter (for polygons) not in contact with any of the other elements of the structure. Thus, the component elements of a multilevel structure may typically be identified and distinguished, presenting at least two levels of detail: that of the overall structure and that of the polygon or polyhedron elements that form it.

Additionally, several multilevel structures may be grouped and coupled electromagnetically to each other to form higher-level structures. In a single multilevel structure, all of the component elements are polygons with the same

number of sides or are polyhedrons with the same number of faces. However, this characteristic may not be true if several multilevel structures of different natures are grouped and electromagnetically coupled to form meta-structures of a higher level.

A multilevel antenna includes at least two levels of detail in the body of the antenna: that of the overall structure and that of the majority of the elements (polygons or polyhedrons) which make it up. This may be achieved by ensuring that the area of contact or intersection (if it exists) between the majority of the elements forming the antenna is only a fraction of the perimeter or surrounding area of said polygons or polyhedrons.

One example property of multilevel antennae is that the radioelectric behavior of the antenna can be similar in more than one frequency band. Antenna input parameters (e.g., impedance and radiation pattern) remain similar for several frequency bands (i.e., the antenna has the same level of adaptation or standing wave relationship in each different band), and often the antenna presents almost identical radiation diagrams at different frequencies. The number of frequency bands is proportional to the number of scales or sizes of the polygonal elements or similar sets in which they are grouped contained in the geometry of the main radiating element.

In addition to their multiband behavior, multilevel structure antennae may have a smaller than usual size as compared to other antennae of a simpler structure (such as those consisting of a single polygon or polyhedron). Additionally, the edge-rich and discontinuity-rich structure of a multilevel antenna may enhance the radiation process, relatively increasing the radiation resistance of the antenna and reducing the quality factor  $Q$  (i.e., increasing its bandwidth).

A multilevel antenna structure may be used in many antenna configurations, such as dipoles, monopoles, patch or microstrip antennae, coplanar antennae, reflector antennae, wound antennae, antenna arrays, or other antenna configurations. In addition, multilevel antenna structures may be formed using many manufacturing techniques, such as printing on a dielectric substrate by photolithography (printed

circuit technique); dieing or stamping on metal plate, repulsion on dielectric, or others.

While the invention has been described with respect to specific examples including presently preferred modes of carrying out the invention, those skilled in the art will appreciate that there are numerous variations and permutations of the above described systems and techniques that fall within the spirit and scope of the invention as set forth in the appended claims.

**Claims:**

1. A chip module (1) comprising:  
  
at least one memory and/or microprocessor chip (12),  
  
and at least one antenna element (2) connected to said chip (12).
2. The chip module of claim 1, **characterized in that** the antenna element (2) is connected to an RF-terminal of the chip (12), preferably by a wire bond (17), a coplanar transmission line (51), a slot line (62) or a strip line.
3. The chip module of claim 1 or 2, **characterized in that** the chip module (1) comprises contact means by which the chip (12) may be connected directly through direct electric contact wherein preferably those contact means comprise pads which are accessible from the outside of the chip module (1).
4. The chip module of claim 3, **characterized in that** those contact means comprise at least 2, 4, 6, 8, 10, 12, 15 or more pads.
5. The chip module of any of claims 1 to 4, **characterized in that** the antenna element (2) is preferably located in an area where there are no contact means or contact pads.
6. The chip module of any of claims 1 to 5, **characterized in that** the chip module (1) is essentially rectangular and with or without a notch (8).
7. The chip module of claim 6, **characterized in that** the antenna element (2) will be in the half of the chip module (1) where there is not the major portion of the contact pads when considering the rectangular shape divided in two equal portions by a line (9a) extending parallel to the short edge of the rectangle.

8. The chip module of any of claims 1 to 7, **characterized in that** in a view perpendicular to the chip module plane, the contact means or contact pads do not overlap with the antenna element (2).
9. The chip module of any of claim 1 to 8, **characterized in that** the antenna element (2) has a conductive pattern which preferably is provided in one, two, three or more planes, while multiple of those planes are preferably parallel to each other.
10. The chip module of any of claims 1 to 9, **characterized in that** the at least one antenna element (2) has a driving point (6).
11. The chip module of claim 10 **characterized in that** the driving point (6) preferably is separated from the chip module edge by at least 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 mm and/or not more than 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 mm.
12. The chip module of any of claims 10 or 11, **characterized in that** the driving point (6) is located not further away from a feeding terminal of the chip than 1, 2, 3, 4, 5, 7, 10, 12, 15, 20, 25, 30, 40, 50 percent of largest extension of the chip module (1).
13. The chip module of any of claims 10 to 12 as far as depending on claim 6 **characterized in that** the driving point (6) may be provided in the half where there is the major portion of the contact pads when considering the rectangular shape divided in two equal portions by a line (9b) extending parallel to the long edge of the rectangle.
14. The chip module of any of claims 1 to 13, **characterized in that** the at least one antenna element (2) includes one, two, three or more connections to a radio frequency ground.
15. The chip module of any of claims 1 to 14, **characterized in that** the antenna element (1) has at least or exactly one, two, three or more termination points



(7).

16. The chip module of claim 15, **characterized in that** at least or exactly one, two, three or more termination points (7) is/are open ended, which means that this end is not electrically connected to any other item.
17. The chip module of claim 15, or 16 **characterized in that** at least or exactly one, two, three or more termination points (7) is/are connected to the chip (12) or to a second antenna element (3).
18. The chip module of any of claims 15 to 17, **characterized in that** the chip module (1) is essentially rectangular and with or without a notch (8), the chip module has four areas separated by two straight lines (9a, 9b) crossing in the middle of the rectangle one being parallel to the short edge and the other being parallel to the long edge of the rectangle, one of those four areas contains the major portion of the contact pad area (4) and a termination point (7) or two or three or more or all termination points are provided in the area which is the diagonally opposite area to that of the contact pads.
19. The chip module of any of claims 1 to 18, **characterized by** comprising a dielectric substrate (10) or by comprising two, three or more dielectric substrates and/or a multilayer substrate.
20. The chip module of any of claims 1 to 19, **characterized in that** the antenna element (2) is provided entirely on one and the same plane.
21. The chip module of claim 20, **characterized in that** the plane is a plane of contact means or contact pads.
22. The chip module of claim 19 or 20, **characterized in that** the antenna element (2) is provided on a different plane or surface or different planes or surfaces than contact means or contact pads.

23. The chip module of any of claims 1 to 22, **characterized in that** the antenna element (2) and/or a second antenna element (3) may be provided on the same surface of a dielectric substrate (10) as the chip (12) or on different surfaces.
24. The chip module of any of claims 1 to 23, **characterized in that** the chip module (1) is compliant with the ISO 7816 standard.
25. The chip module of any of claims 1 to 24, **characterized in that** chip module (1) is a SIM card, such as e.g. for a wireless phone (25) or handheld wireless device or a multifunctional wireless device.
26. The chip module of any of claims 1 to 25, **characterized in that** the chip module (1) comprises a microprocessor and/or a radio frequency chip which is suitable for generating and/or receiving radio frequency signals which can then be fed to the antenna element (2) or antenna elements.
27. The chip module of any of claims 1 to 26, **characterized in that** it comprises a second antenna element (3) such as e.g. a ground plane or a ground counterpoise or a second arm of the dipole antenna, where the other arm is given by the first antenna element (2).
28. The chip module of claim 27 as far as depending on claim 3, **characterized in that** in a view perpendicular to the chip module plane, the contact means or contact pads do not overlap the second antenna element (3).
29. The chip module of any of claims 27 or 28, **characterized in that** except for a feeding point (6), the antenna element (2) may be separated from the second antenna element (3) by a minimum distance of at least 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 mm and/or not more than 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 mm wherein a distance between 1 and 3 mm is preferred.
30. The chip module of any of claims 27 to 29, **characterized in that** the second

antenna element (3) is connected to the chip (12), in particular, to an RF terminal of the chip and/or a ground terminal.

31. The chip module of any of claims 27 to 30, **characterized in that** in a view onto the chip module (1) in which the chip module appears with the largest size, the second antenna element (3) may cover a certain percentage of the chip module size such as e.g., more than 10, 20, 30, 40, 50, 60, 70, 80, 85 or 90 percent and/or it may cover less than 20, 30, 40, 50, 60, 70, 80, 85, 90 or 95 percent.
32. The chip module of any of claims 27 to 31, **characterized in that** the second antenna element (3) covers in a plane where there are no other conductive elements 100% of the size, wherein in such a case the first antenna element (2) will be provided below or above this second antenna element (3).
33. The chip module of any of claims 27 to 32, **characterized in that** the first and second antenna element (2, 3) may be provided in the same plane or on the same surface of a dielectric substrate (10) or on different planes or surfaces.
34. The chip module of any of claims 27 to 33, **characterized in that** the first antenna element (2) has a termination point (7) which is closer to a chip module border than to the second antenna element (3), wherein the termination point preferably is close to or at a chip module border which does not limit the first antenna element (2).
35. The chip module of any of claims 27 to 34, **characterized in that** the second antenna element (3) has one, two, three or more clearances (5, 18) wherein a clearance in the second antenna element (3) is an area in the plane of the second antenna element (3) where there is no portion of the second antenna element (3).
36. The chip module of claim 35, **characterized in that** a clearance (5, 18) is used for locating the first antenna element (2) or for locating contact

means/pads and/or for locating a chip that extends in or into the plane of the second antenna element (3).

37. The chip module of claim 35 or 36, **characterized in that** the clearance (5) which accommodates the first antenna element (2) is provided next to a notch (8) of the chip module (1).
38. The chip module of any of claims 35 to 37, **characterized in that** the area covered by the clearance (5) in which the first antenna element is provided is more or less than a percentage of 10, 20, 30, 40, 50, 60, 70, 80, or 90 percent of the area covered by the second antenna element (3), preferably between 40 and 70 percent.
39. The chip module of any of claims 35 to 38, **characterized in that** the clearance (18) in which the contact pads are provided can be made such that it surrounds and encloses the contact pads in a view perpendicular onto the chip module (1).
40. The chip module of any of claims 1 to 39, **characterized in that** the antenna element (2) comprises at least 4, 5, 6, 7, 8, 9, 10, 12, 15, 17, 20, 25 or 30 segments (2a, 2b, 2c), while a segment (2a, 2b, 2c) may be straight or curved.
41. The chip module of any of claims 27 to 40 as far as depending on claim 27, **characterized in that** the second antenna element (3) comprises at least 4, 5, 6, 7, 8, 9, 10, 12, 15, 17, 20, 25 or 30 segments (2a, 2b, 2c), while a segment may be straight or curved.
42. The chip module of any of claims 40 or 41 **characterized in that** right and left curved segments are provided and/or that at connection points of a straight segment angles to the left and to the right are provided.
43. The chip module of claim 42, **characterized in that** the number of left and

right curved segments does not differ by more than 80, 70, 60, 50, 40, 30, 20 or 10% of the larger of the two numbers.

44. The chip module of claim 42 or 43, **characterized in that** the number of connection angles between adjacent segments which following the curve go to the right and those that go to the left do not differ by more than 80, 70, 60, 50, 40, 30, 20 or 10% of the larger of the two numbers.
45. The chip module of any of claims 42 to 44, **characterized in that** the number of the left curved segments plus the number of the connections points where the curve turns left and the number of the right curved segments plus the number of connection points where the curve turns right do not differ by more than 80, 70, 60, 50, 40, 30, 20 or 10% of the larger of the two numbers.
46. The chip module of any of claims 1 to 45, **characterized in that** the antenna element (2) is shaped according to a space filling curve, a box counting curve, a grid dimension curve or a multilevel structure.
47. The chip module of any of claims 27 to 46, as far as depending on claim 27, **characterized in that** the second antenna element (3) is shaped according to a space filling curve, a box counting curve, a grid dimension curve or a multilevel structure.
48. The chip module of any of claims 1 to 47, **characterized in that** the chip module has an essentially rectangular outer shape with a notch (8) in one corner in order to identify the orientation of the chip module and hence the location of optional contact pads.
49. The chip module of any of claims 1 to 48, **characterized in that** the chip module (1) has a length of 25 mm and/or a width of 10 mm.
50. The chip module of any of claims 1 to 49, **characterized in that** the antenna element (2) is a slot and/or a monopole or a dipole or part of a dipole.

51. The chip module of any of claims 27 to 50 as far as depending of claim 27, **characterized in that** second antenna element (3) may be connected to a contact pad that is used for grounding purposes.
52. The chip module of any of claims 1 to 51, **characterized in that** a ground plane is not connected to any contact pad.
53. The chip module of any of claims 1 to 52, **characterized in that** between the chip (12) and the antenna element (2), a passive network and/or an active network is provided, wherein the network may be a matching network, a filter or a balun network.
54. The chip module of any of claims 27 to 53, as far as depending on claim 27, **characterized in that** between the chip (12) and the second antenna element (3), a passive network and/or an active network is provided, wherein the network may be a matching network, a filter or a balun network.
55. The chip module of any of claims 1 to 54, **characterized in that** the chip module (1) is adapted for wireless operation in a range of up to 3 to 5 m.
56. The chip module of any of claims 1 to 55, **characterized in that** the chip module (1) is adapted for operation in the far field, which means, that data transmission via the wireless connection is carried out between devices which are separated by more than a half-wavelength.
57. The chip module of any of claims 1 to 56, **characterized in that** operation frequencies are above 800 MHz such as for example 868 MHz, 915 MHz or 2.4 GHz or any other ISM band.
58. The chip module of any of claims 1 to 57, **characterized in that** the chip module (1) has a largest thickness of less than 1.5, 1.2, 1.0, 0.9, 0.8, 0.7, 0.6 or 0.5 mm and/or a largest thickness of more than 0.6, 0.7, 0.8, 0.9, 1.0, 1.2,

or 1.5 mm, wherein a thickness of  $0.8 \pm 0.05$  mm is preferred.

59. The chip module of any of claims 1 to 58, **characterized in that** the chip module (1) comprises two, three or more chips, wherein one of said chips is a memory.
60. A wireless device (25) comprising a chip module as of any of claims 1 to 59.
61. The wireless device of claim 60, **characterized in that** the wireless device (25) is a cellular phone.
62. The wireless device of any of claims 60 or 61, **characterized in that** the wireless device (25) is a multifunctional wireless device such as e.g. a PDA.
63. The wireless device of any of claims 60 to 62, **characterized in that** the first and/or second antenna element (2, 3) is preferably separated from the ground (35) of the wireless device (25) and/or from the battery (26) of the wireless device by more than 0.5, 0.7, 1.0, 1.2 or 1.5 mm and/or less than 5, 4, 3, 2 or 1 mm.
64. The wireless device of any of claims 60 to 63, **characterized in that** the ground (3) of the chip module (1) is preferably connected to the ground (35) of the wireless device (25), wherein this connection maybe ohmic or capacitive or inductive.
65. The wireless device of any of claims 60 to 64 **characterized in that**, the wireless device (25) comprises a battery (26), wherein such a battery (26) may have a ground contact (29) with which it may be connected to the ground (30, 35) of the wireless device (25).
66. The wireless device of any of claims 60 to 65, **characterized in that** the wireless device comprises a display, such as e.g. an LCD and/or a digital connector and/or a power supply connector and/or a Bluetooth/WIFI antenna

(28) and/or an antenna (27) of a mobile telephone system, wherein the chip module (1) is preferably separated from the

- ground contact (29) of the battery (26) and/or
- the ground contact of the display and/or
- the ground contact of the digital connector or power supply connector and/or
- a grounded element or ground contact of the mobile telephone system antenna (27) and/or
- a mobile telephone system antenna (27) itself and/or
- a Bluetooth/WIFI antenna (28)

by at least 20, 30, 40, 50, 60, 70 or 80 percent of the largest extension of the wireless device (25).

67. The wireless device of any of claims 60 to 66, **characterized in that** the wireless device (25) has a chip module holder, which preferably is made of or comprises plastic or dielectric materials.
68. The wireless device of claim 67, **characterized in that** no metallic or conductive materials are provided in the holder.
69. The wireless device of any of claims 60 to 68, **characterized in that** the chip module (1) is preferably arranged in such an orientation that the antenna element (2) shows to the periphery while the second antenna element (3) shows towards the interior of the wireless device (25), when the chip module (1) is substantially parallel to the ground plane (35) of the wireless device.
70. The wireless device of any of claims 60 to 69, **characterized in that** the chip



module (1) is removable from the wireless device (25).

71. A SIM card (1) comprising:

a dielectric substrate (10),

eight or more contact pads provided on one side of said dielectric substrate (10),

at least one memory and/or microprocessor chip (12) provided on the other side of the substrate (10) and connected to said contact pads,

a first antenna element (2) provided on the same side of the dielectric substrate (10) as the chip (12), wherein the first antenna element (2) has at least one driving point (6) and at least one termination point (7),

a second antenna element (3) provided on the same side of the dielectric substrate (10) as the first antenna element (2),

wherein the first antenna element (2) is given in an area different from the area where the contact pads are arranged,

and the chip (12) can be accessed by a wireless communication link with help of the first and second antenna element (2, 3) operating at a frequency of more than 800 MHz,

and wherein the first antenna element (2) is shaped according to a space filling curve

which has a driving point (6) closer than 3 mm to the second antenna element (3) and

which has at least one termination point (7) which is further away from the

second antenna element (3) than 6 mm.

72. A wireless device (25) with a SIM card as of claim 71.

73. Wireless communication method comprising the steps of:

accessing a wireless device as of any of claims 60 to 70 by establishing a wireless connection between the chip module (1) and a device outside of the wireless device (25) which is preferably separated from the wireless device (25) by more than a free space operating wavelength.

74. Wireless communication method comprising the steps of:

accessing a wireless device as of claim 72 by establishing a wireless connection between the SIM card (1) and a device outside of the wireless device (25) which is preferably separated from the wireless device (25) by more than a free space operating wavelength of the wireless connection.

75. The method of claim 73 or 74, **characterized in that** information is read out from the chip (12).

76. The method of claim 75, **characterized in that** with the read out information the device may perform actions which are only possible with the data of the chip module (1), without, however, this device actually having the chip module (1) incorporated, wherein those actions include for example financial transactions or telephone calls, or the like.

77. The method of claim 75 or 76, **characterized in that** with the read out information the device executes a remote payment transaction with a mobile phone or wireless device (25) including the chip module (1) without connecting to a mobile or cellular network.

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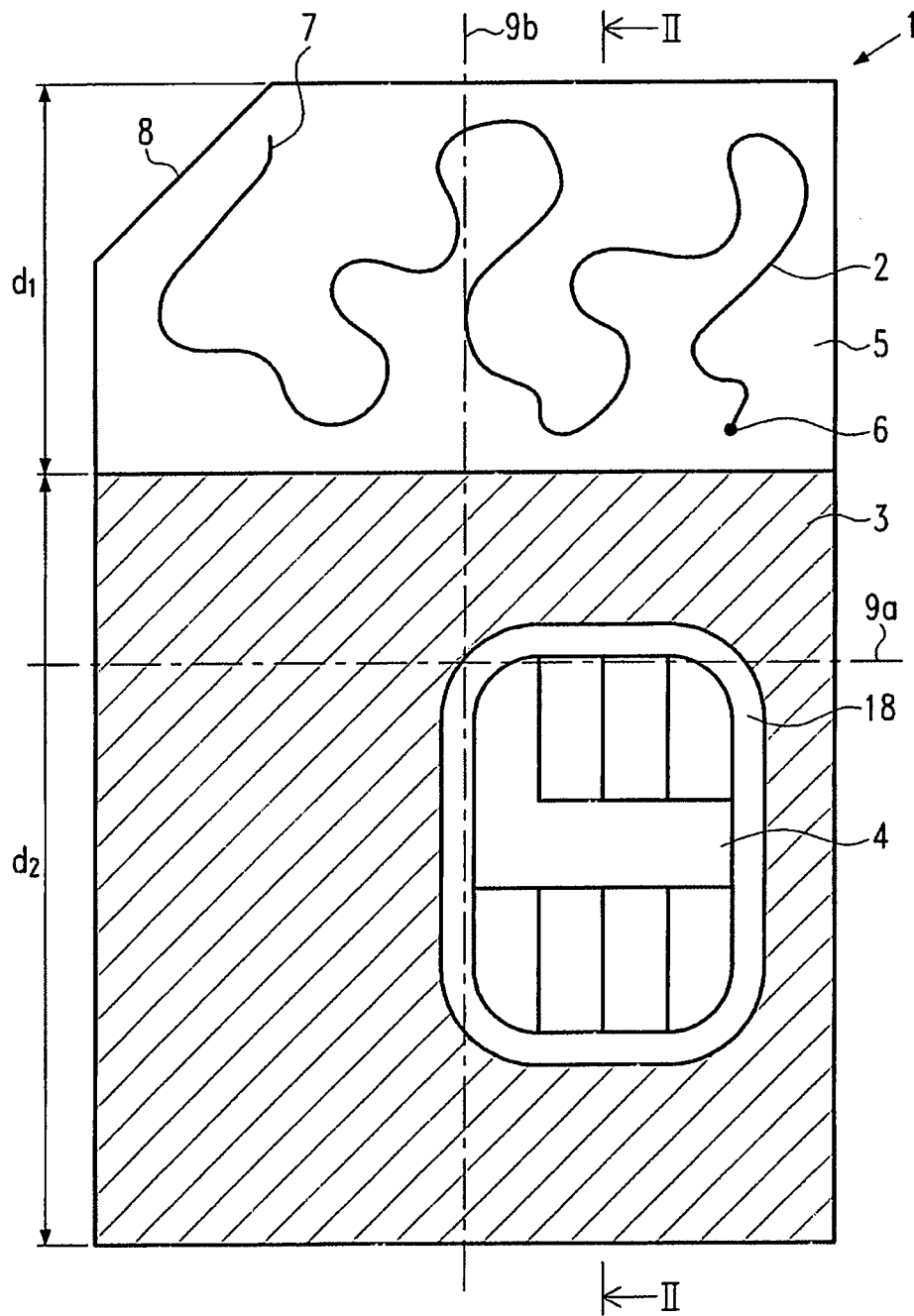


FIG.1

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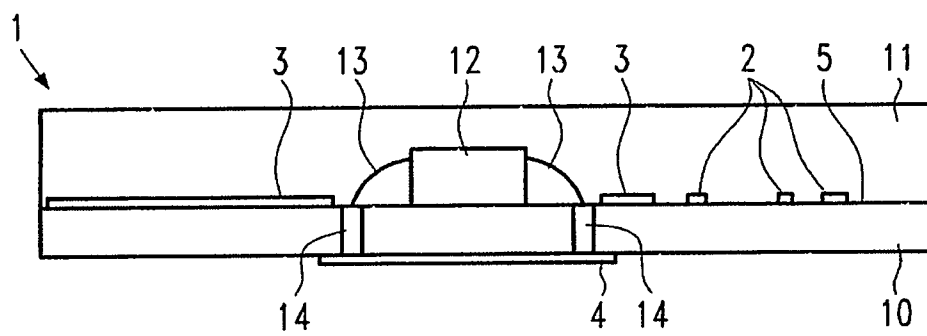


FIG.2

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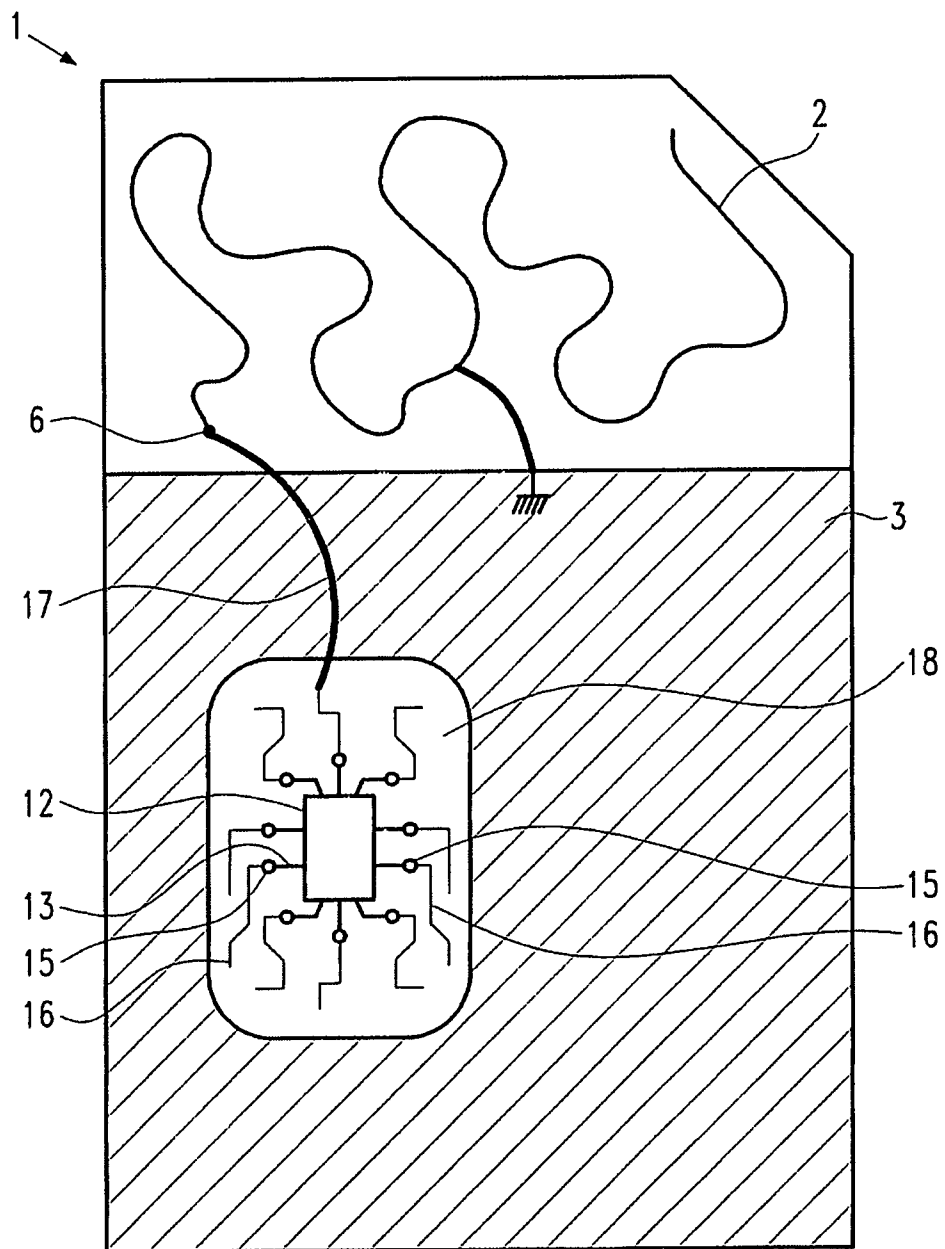
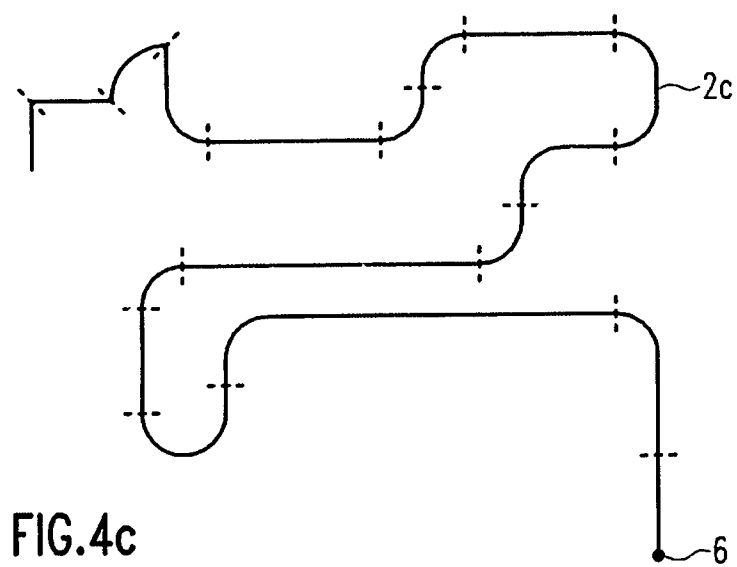
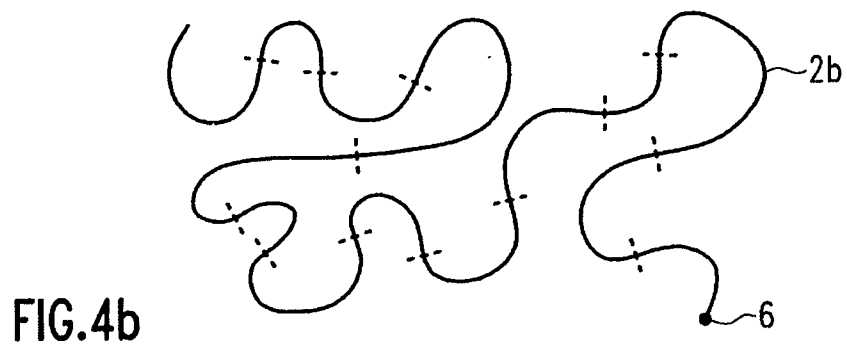
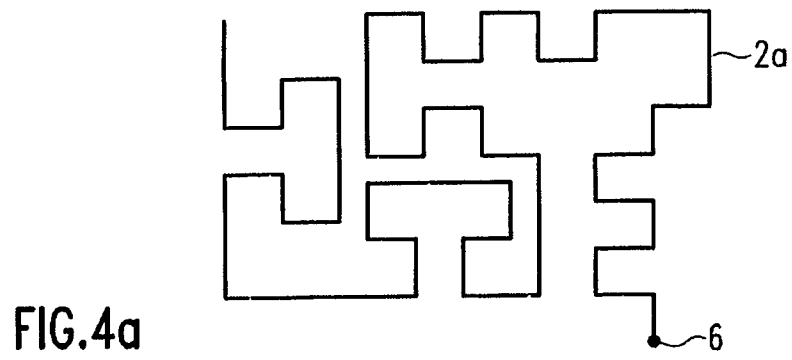


FIG.3

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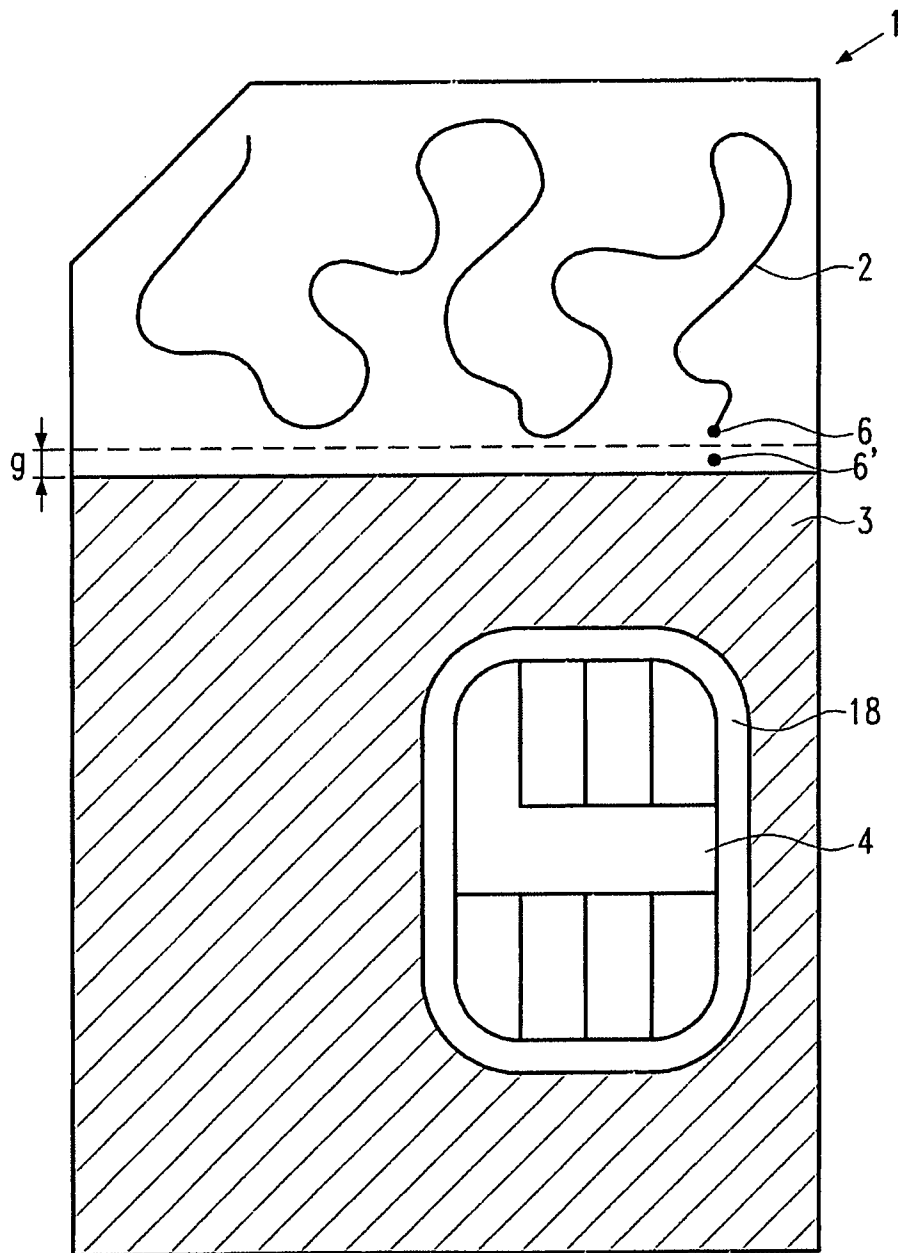


FIG.5

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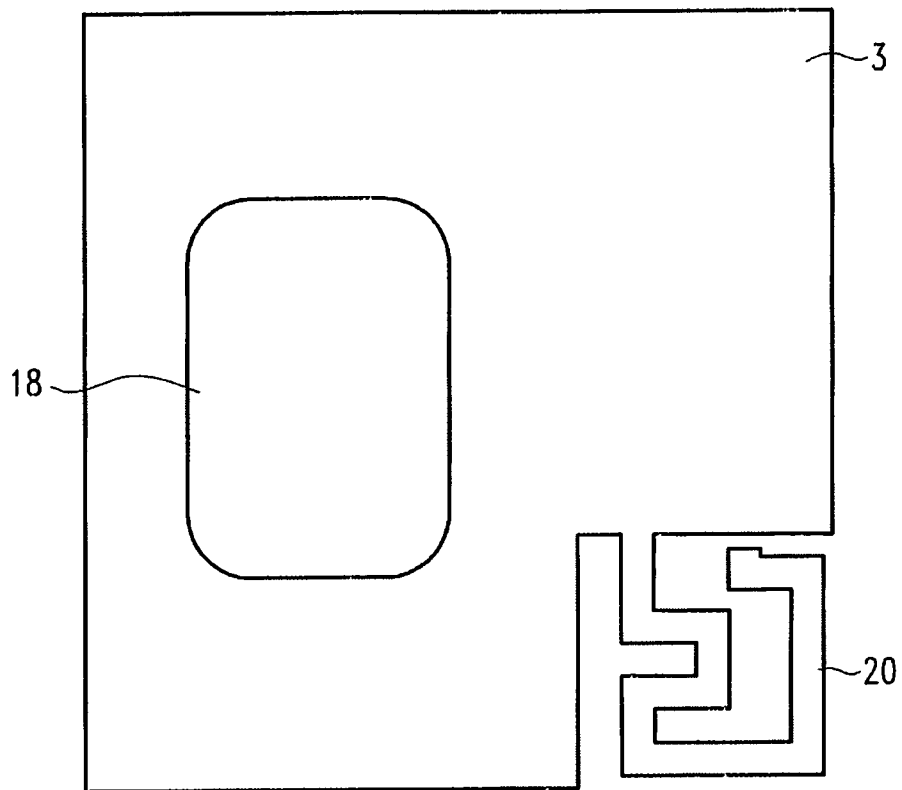


FIG.6



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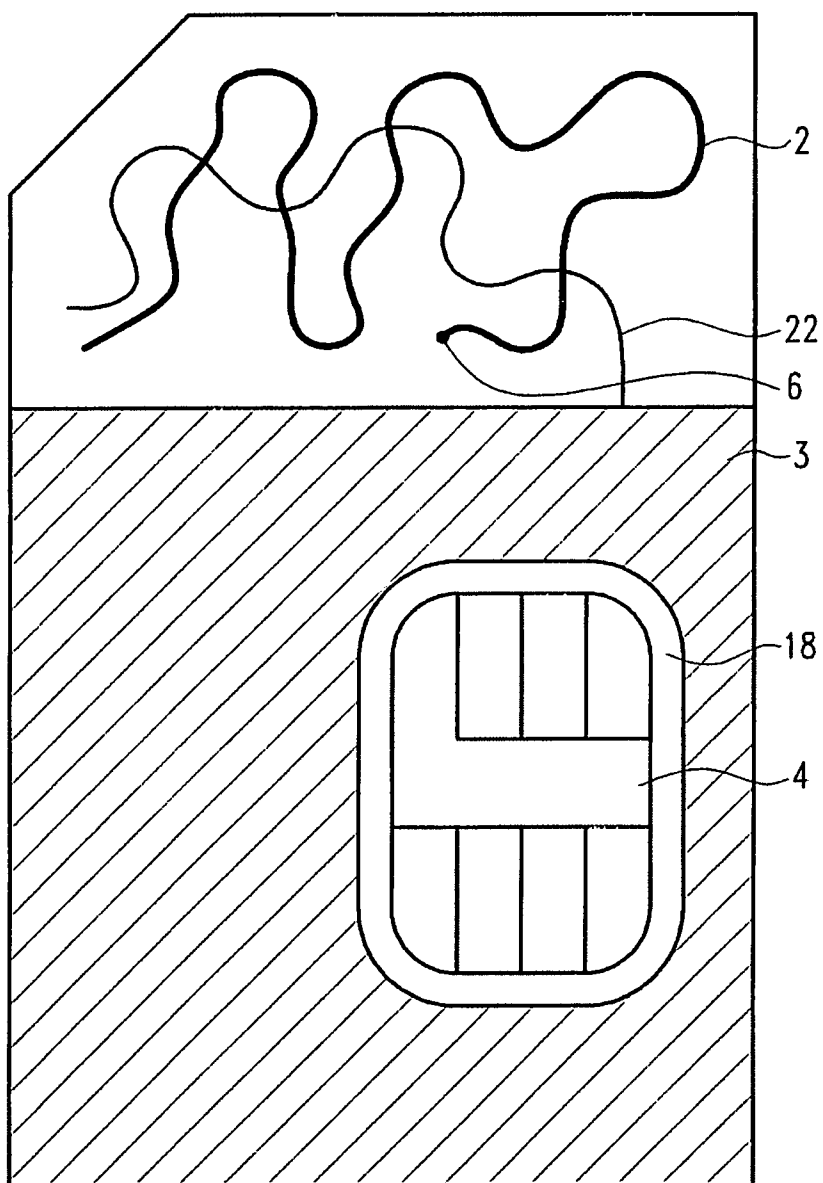
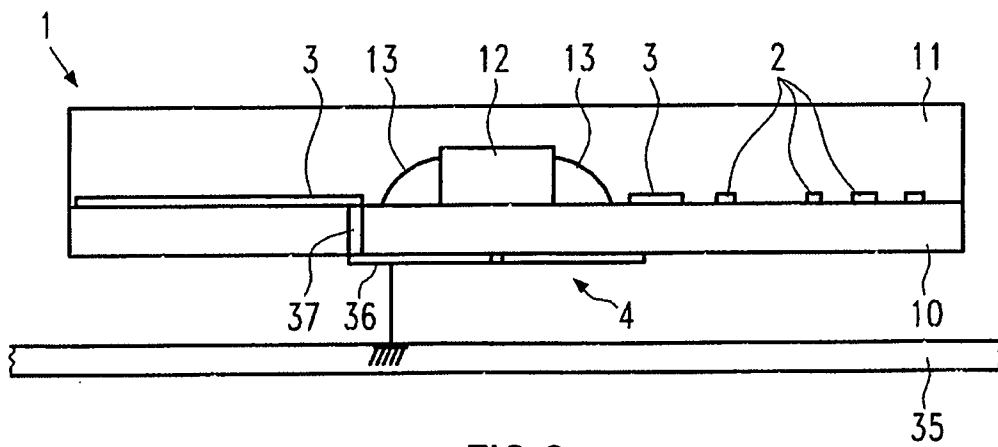
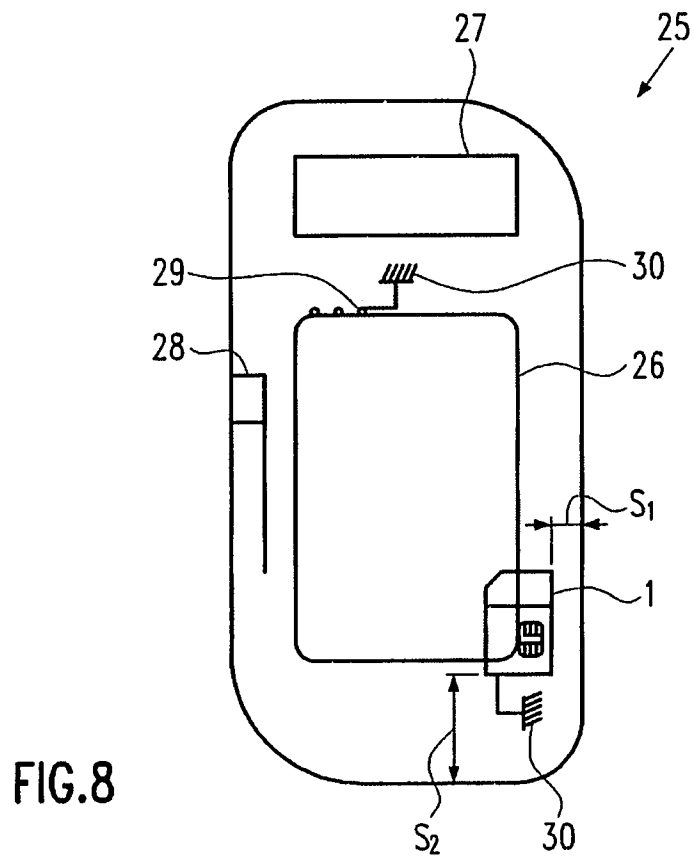


FIG.7

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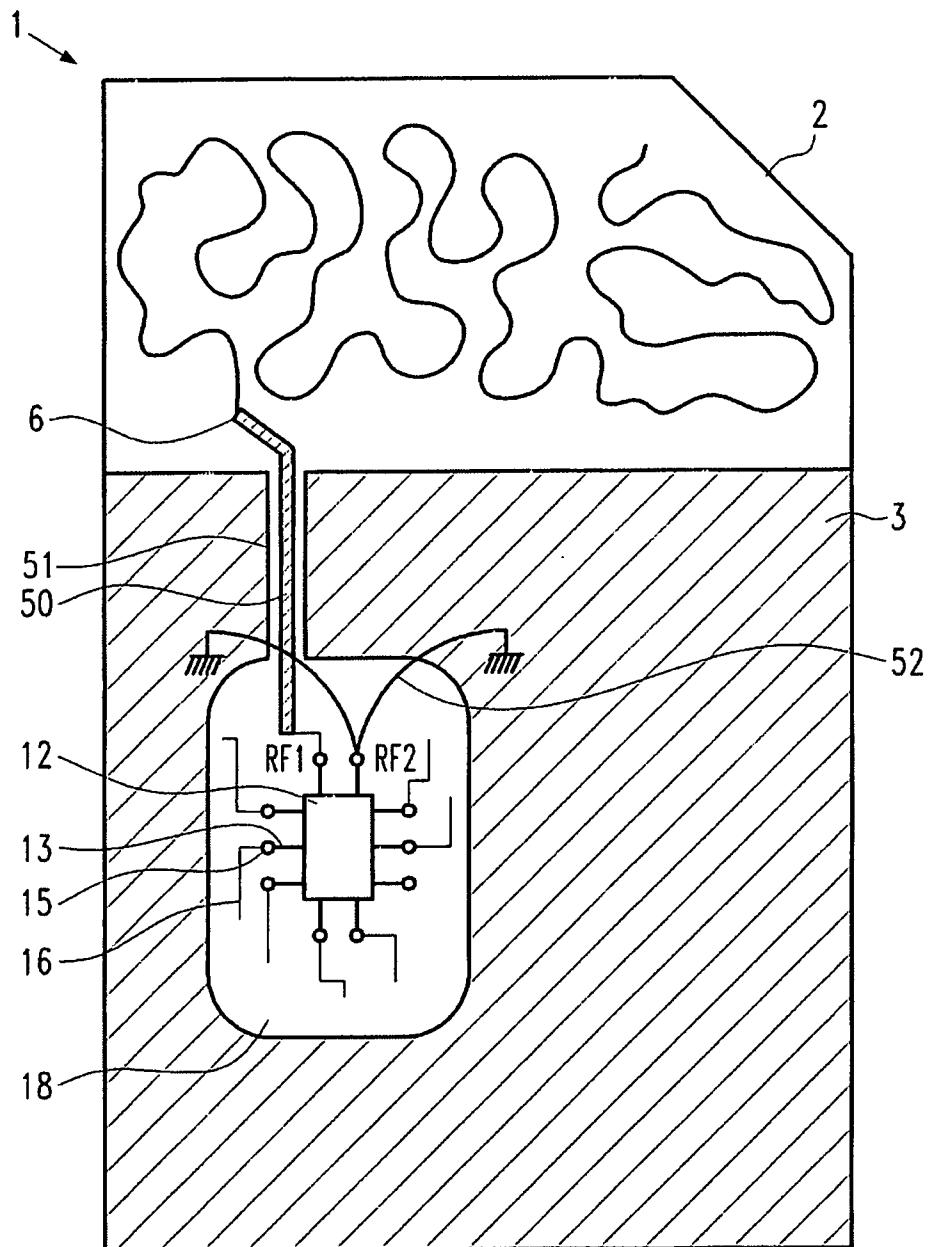


FIG.10

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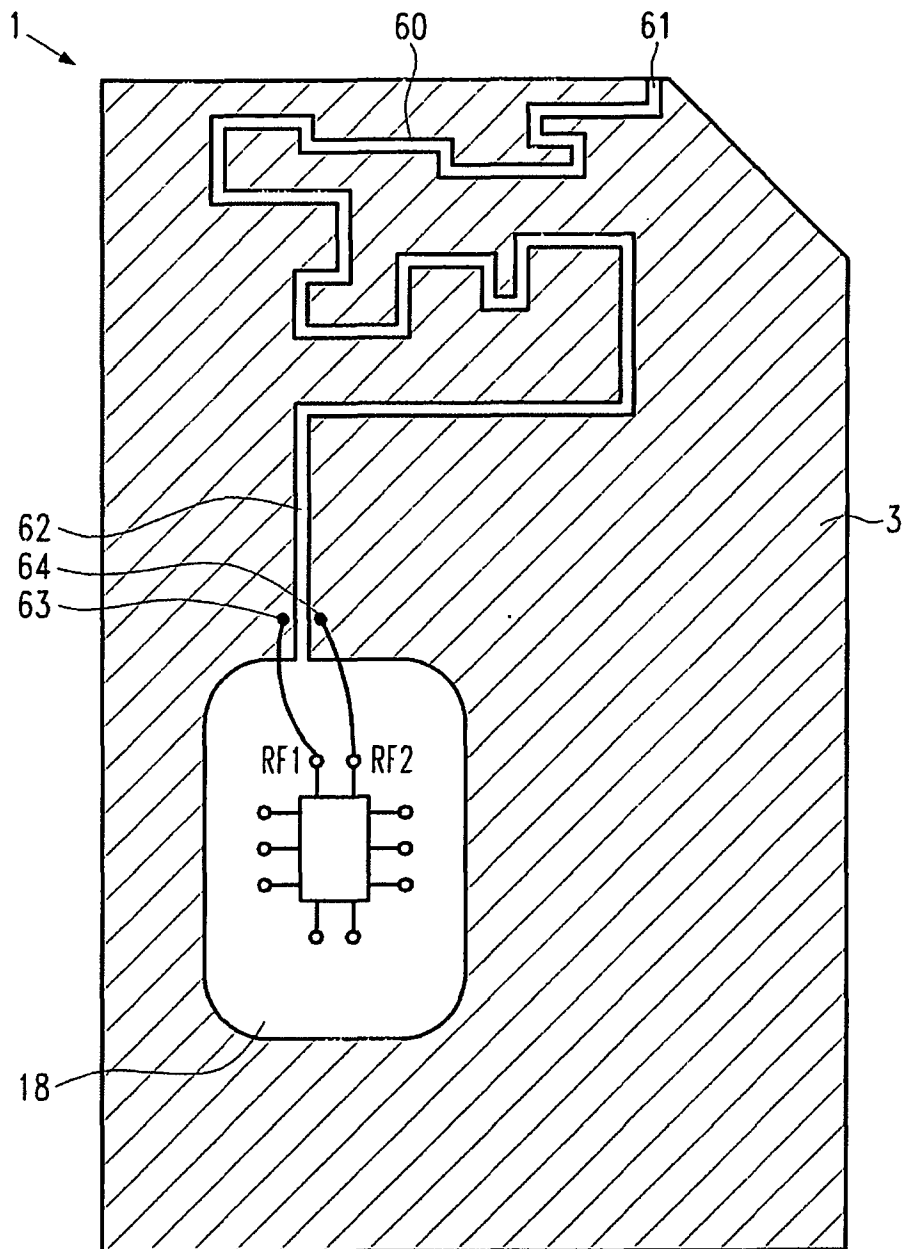


FIG.11

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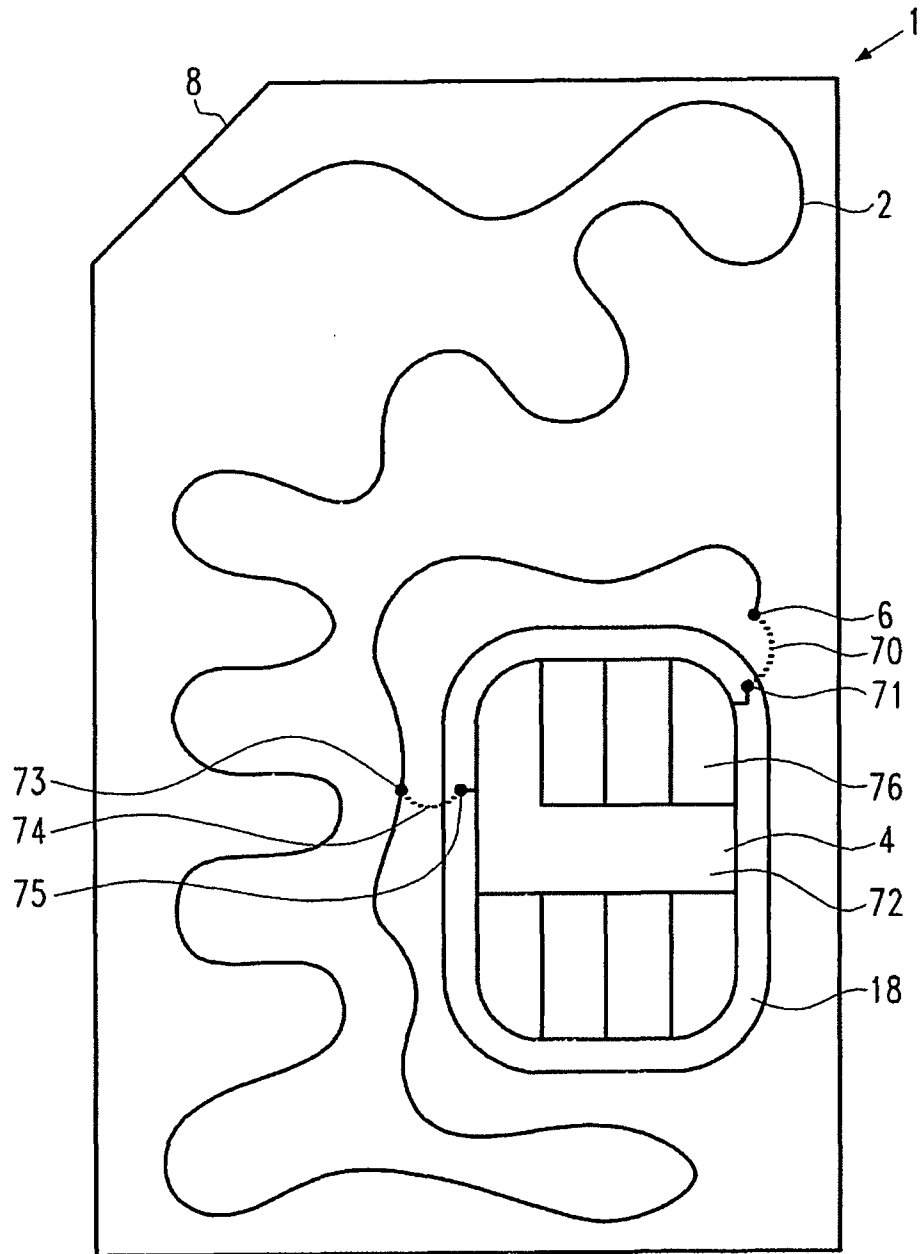


FIG.12

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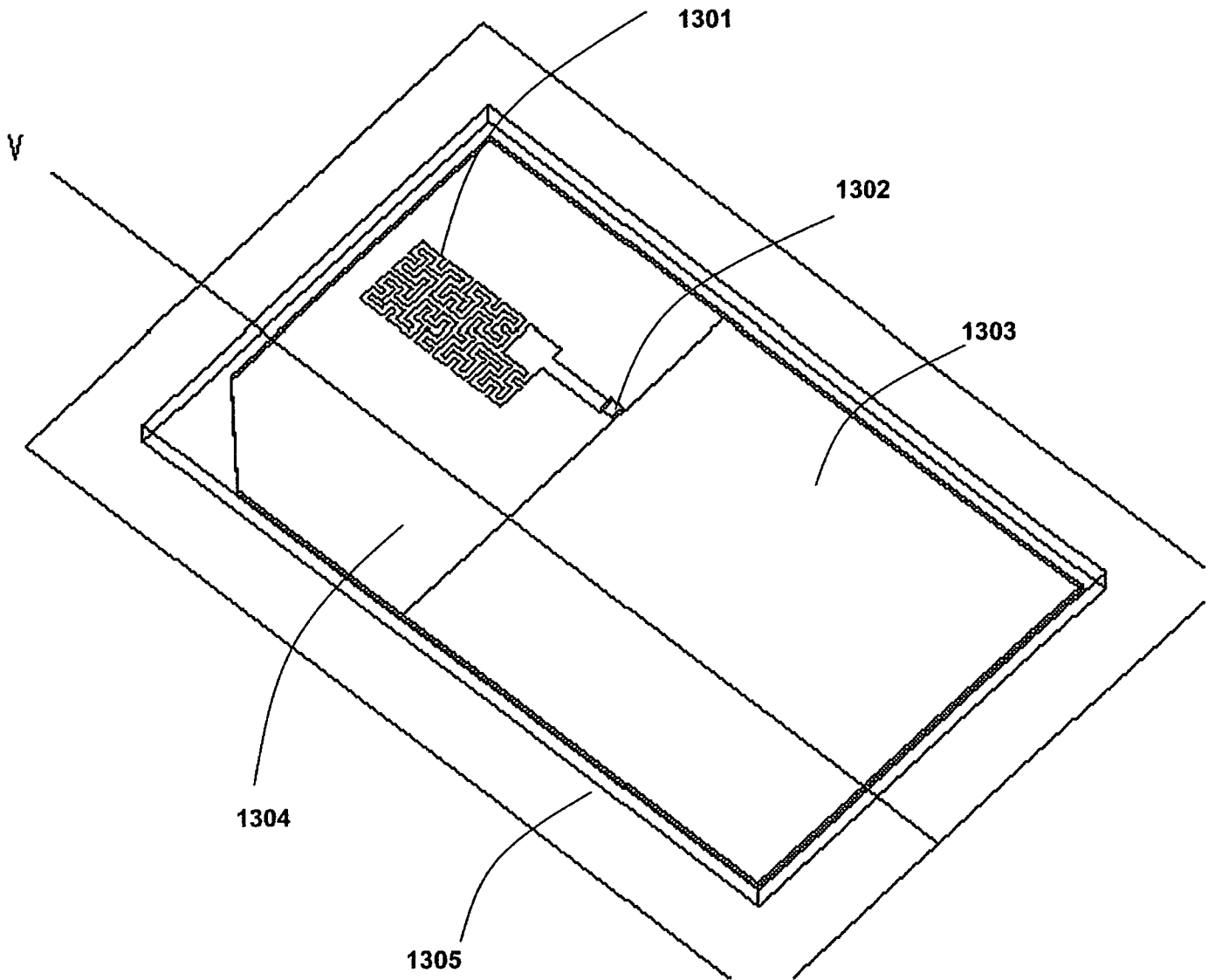


FIG.13

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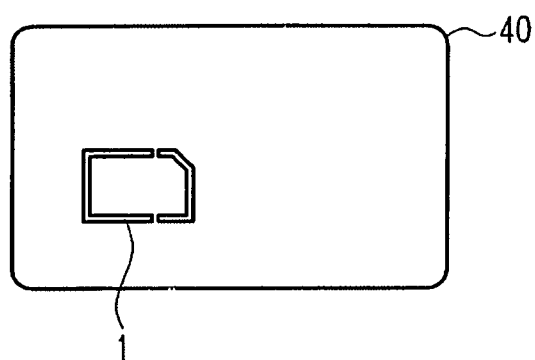


FIG. 14

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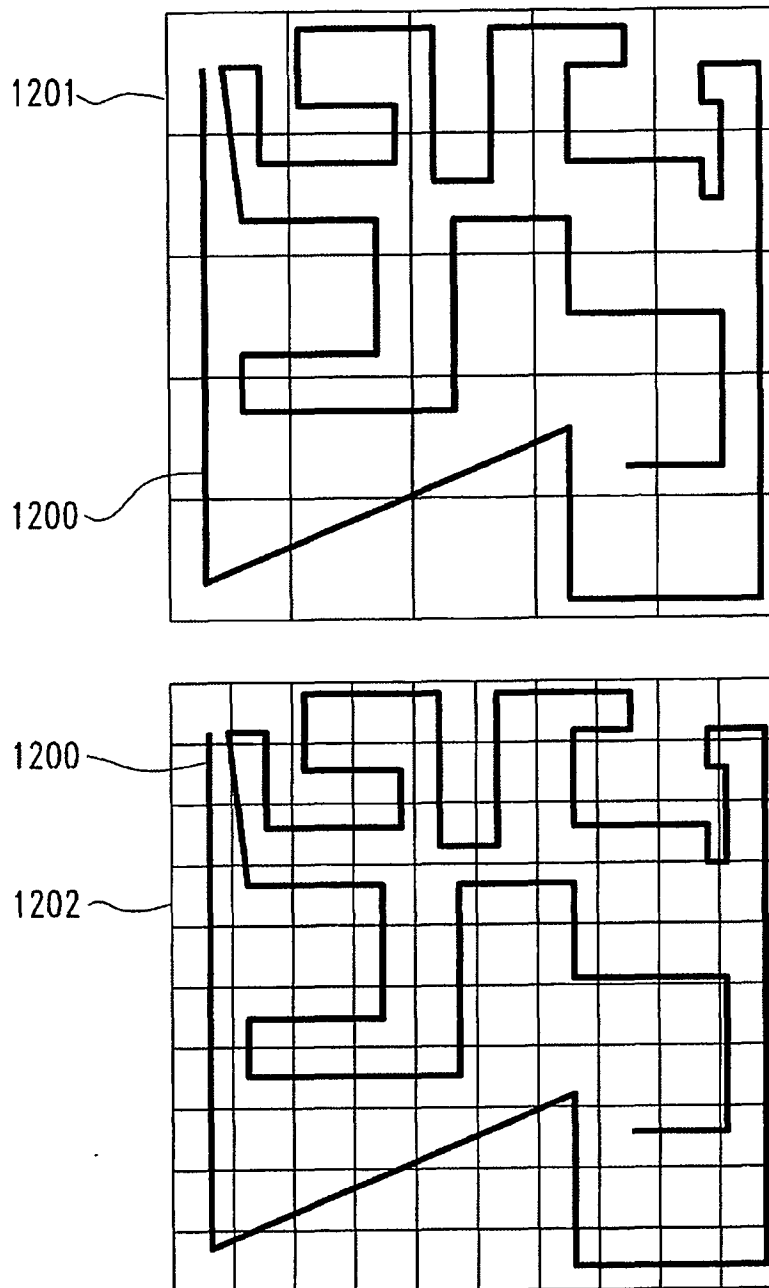


FIG. 15



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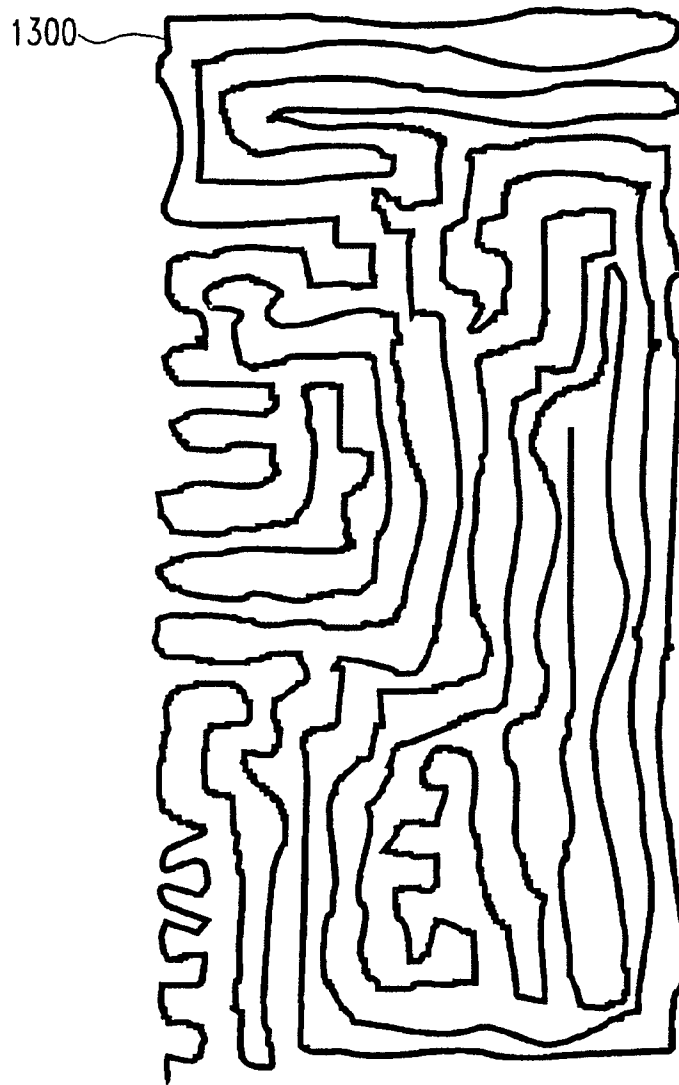


FIG. 16

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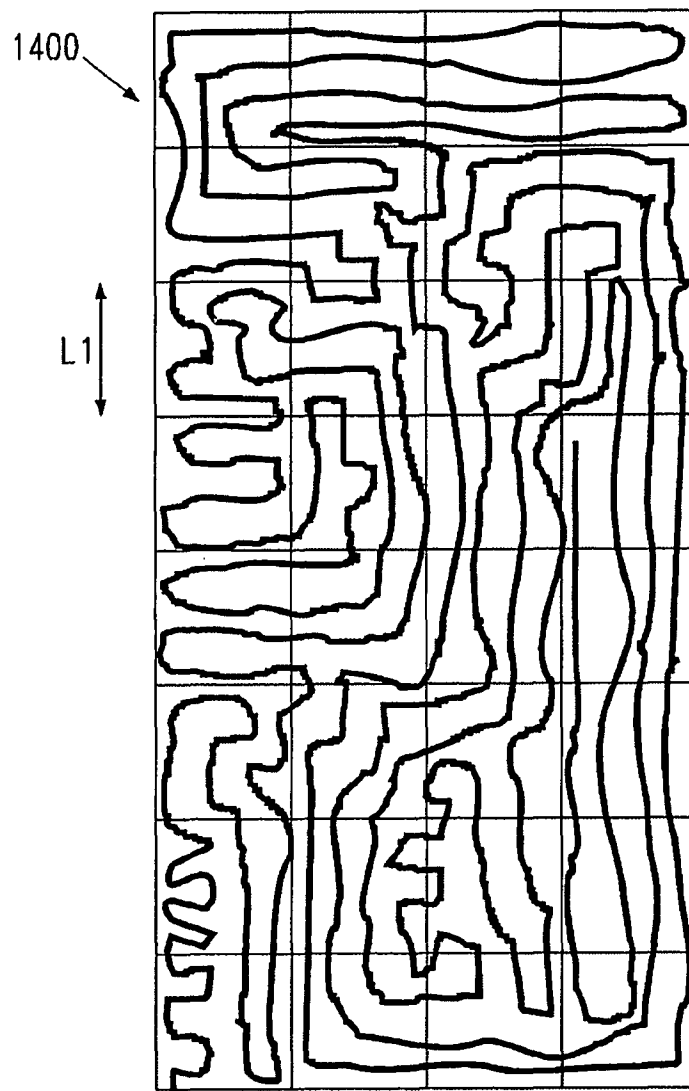


FIG. 17

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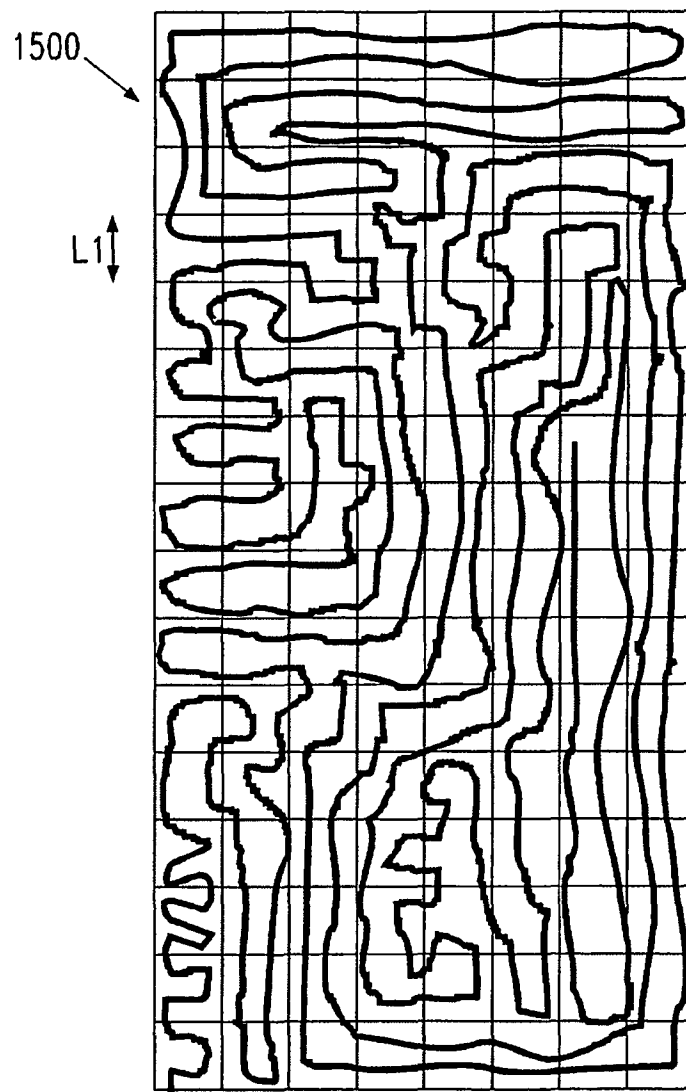


FIG. 18

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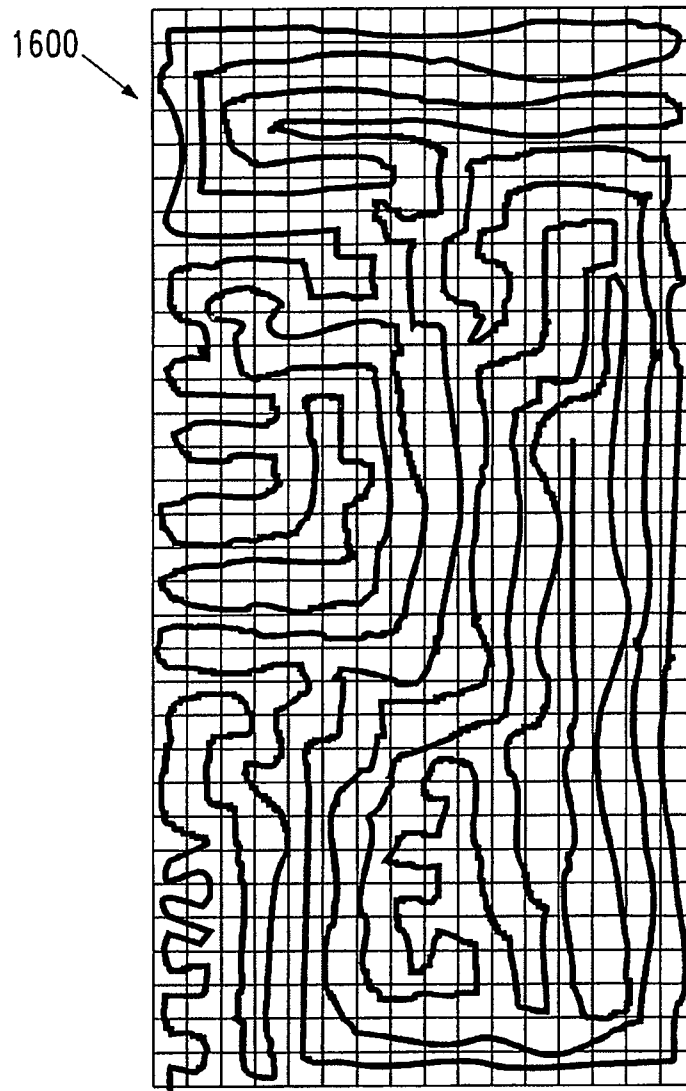


FIG. 19

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2007/005547

A. CLASSIFICATION OF SUBJECT MATTER  
INV. G06K19/077

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
G06K

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/019261 A (DAINIPPON PRINTING CO LTD [JP]; NISHIKAWA SEIICHI [JP]) 4 March 2004 (2004-03-04)	1-6, 8-15,17, 18
Y	abstract page 3 - page 11 figures 1,4	16
X	EP 0 822 512 A2 (ODS GMBH & CO KG [DE] GEMPLUS GMBH [DE]) 4 February 1998 (1998-02-04) the whole document	1-10,12, 13
Y	WO 2005/076409 A (FRACTUS S A [ES]; SOLER CASTANNY JORDI [ES]; PUENTE BALIARDA CARLES [E]) 18 August 2005 (2005-08-18) abstract figures 1-4	16

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

☒ See patent family annex.

## \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\* & \* document member of the same patent family

Date of the actual completion of the international search

11 September 2007

Date of mailing of the international search report

03/12/2007

Name and mailing address of the ISA/

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Authorized officer

Berger, Christian

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/EP2007/005547

### Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers allsearchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search reportcovers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

see annex

#### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-18,20-26,40,48,49,52,55-58

The subject-matter of claim 1-15, 17, 18, 20-26, 40, 48, 49,52 and 55-58 is known or immediately obvious from documents EP0822512 and/or WO2004/019261 (cf. WOISA). Claim 16 which is dependent on claim 1 claims one or more open ended termination points and concerns the problem of how to use reference potential external to the chip module.

---

2. claim: 19

The subject-matter of claim 1 is known from documents EP0822512 and WO2004/019261. Claim 19 which is dependent on claim 1 claims a chip module comprising a certain dielectric substrate structure and concerns the problem of improving the transmission behaviour of the chip module.

---

3. claims: 27-39,41-45,47,51,54,71,72,74-77

The subject-matter of claim 1 is known from documents EP0822512 and WO2004/019261. Claim 27 which is dependent on claim 1 claims a chip module comprising a second antenna element. Independent claim 71 claims a SIM card comprising a microprocessor chip and two antenna elements. Both claims concern the problem of how to improve antenna directivity.

---

4. claims: 46,50

The subject-matter of claim 1 is known from documents EP0822512 and WO2004/019261. Claims 46 and 50, each being dependent on claim 1, claim a chip module comprising a specially shaped antenna element and concerns the problem of how to miniaturise an antenna structure.

---

5. claim: 53

The subject-matter of claim 1 is known from documents EP0822512 and WO2004/019261. Claim 53 which is dependent on claim 1 claims a chip module comprising a network between the chip and the antenna element and concerns the problem of how to improve antenna gain.

---

6. claim: 59

The subject-matter of claim 1 is known from documents EP0822512 and W02004/019261. Claim 59 which is dependent on claim 1 claims a chip module comprising several chips of which at least one is a memory and concerns the problem of combining several functions on one chip module.

---

7. claims: 60-70,73

The subject-matter of claim 1 is known from documents EP0822512 and W02004/019261. Claim 60 claims a wireless device comprising the chip module of claim 1 and concerns the problem of how to provide an application for the chip module.

---



# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2007/005547

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 2004019261	A	04-03-2004	AU 2003257688 A1	11-03-2004
			CN 1679048 A	05-10-2005
			EP 1535240 A2	01-06-2005
			KR 20050031463 A	06-04-2005
			US 2005212690 A1	29-09-2005
EP 0822512	A2	04-02-1998	AT 339739 T	15-10-2006
			DE 19630947 A1	05-02-1998
WO 2005076409	A	18-08-2005	EP 1714353 A1	25-10-2006