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(54) **Ring-shaped embedded antenna**

(57) An embedded antenna, with a ring-shaped structure is described.

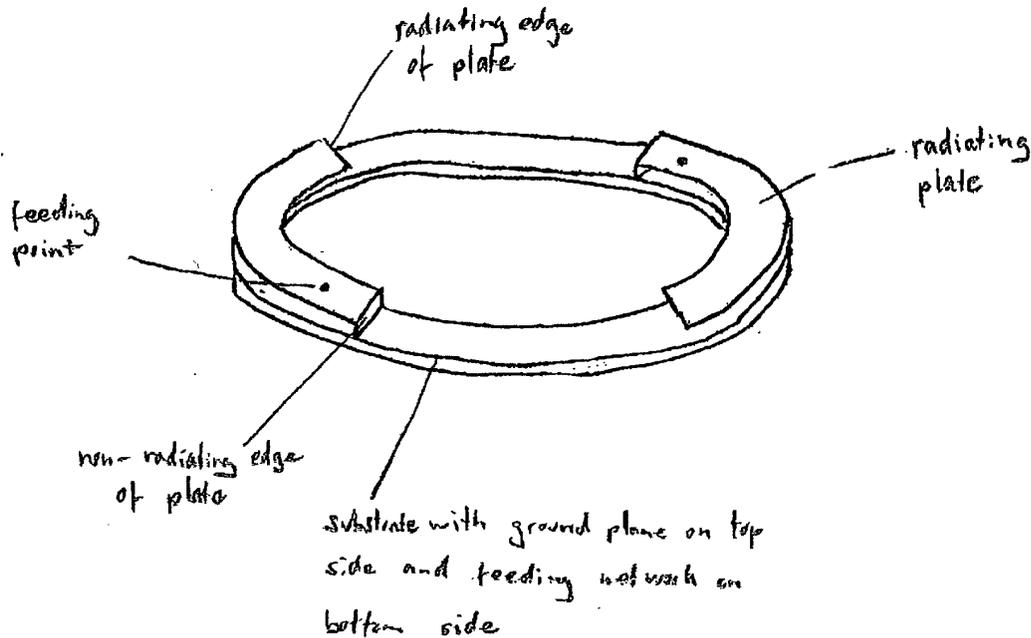


Figure 1

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Description**Background of the invention**

Field of the invention

[0001] The present invention relates to a ring shaped antenna based on a number of independent radiating elements.

Description of the related art

[0002] Typical embedded antennas used in modem communication systems are built of contiguous, closed structures. In their most simple form, these can be e. g. rectangular, triangular or circular shapes. They usually have to be placed in a dedicated space on the PCB reserved exclusively for their placement. No components can be placed underneath, on top or close-by the antenna.

Summary

[0003] The present invention solves these and other problems by providing an antenna design that can be implemented as a ring-shaped structure. It is possible to place components inside this ring. The antenna does not necessarily have to be a circular ring. Elliptical, oval or rectangular shapes are also possible among many others. The antenna itself is built out of a number of independent plates, that can be fed with the same signal, but using different amplitudes and phase relations. By doing this, the polarisation and the radiation pattern can be adapted.

Description of the figures

[0004] The above and other aspects, features, and advantages of the present invention will be more apparent from the following description thereof presented in connection with the following drawings.

Figure 1: General implementation of ring-shaped embedded antenna.

Figure 2: Slot coupled radiating plates.

Figure 3: Examples of possible shapes of ring-shaped embedded antenna.

Figure 4: Ring-shaped antenna with reduced separation between elements.

Figure 5: Distributed feeding network used to provide adequate signals to the plates.

Figure 6: Configuration of ring-shaped antenna with circular polarisation.

Detailed description

[0005] The main field of application for the here-described ring-shaped embedded antenna are miniature communication devices, where a small form factor and the possibility of integrating a high amount of components is of paramount importance. This is e. g. the case for miniaturised GPS receivers, pagers, cellular phones or other appliances that are built-into small housings like e. g. a wrist-watch or a key ring among many others. The minimum frequency of operation of this antenna should be in the area of at least two hundred Megahertz. Otherwise, the antenna will have too large dimensions that in some cases might not be applicable.

[0006] The ring-shaped antenna is best implemented as an embedded antenna. It consists of a minimum of two radiating plates, as shown in Figure 1, which are placed above a conducting ground plane and connected on one side to the latter. The maximum amount of such plates only limited by space requirements. Though increasing the number of plates above a certain amount might no longer increase the performance of the antenna in terms of gain or radiation pattern.

[0007] The plates have a non-radiating and a radiating edge. The former is related to the side where the plate joins the ground plane. The latter is opposite to the non-radiating edge and is related to the open side of the plate.

[0008] There are mainly two ways of how to couple a signal to one of these plates. The simplest is to use a galvanic coupling, which is implemented as a probe connected to a certain point of the antenna. The location of this probe defines the impedance of the port. Low impedance can be achieved by placing the probe close to the connection to ground. High impedance is achieved increasing the separation between the ground connection and the probe.

[0009] A second feeding technique uses slot coupling, as shown in Figure 2. Slots are introduced at certain locations underneath the plates to couple the signal distributed by the feeding network to the plates.

[0010] The radiating plates are placed in a ring-shaped configuration. The ring does not necessarily have to be circular. Elliptical, oval or even rectangular configurations among many others are possible, as shown in Figure 3.

[0011] To most adequately fit the ring shape, the plates should be adapted to this geometry. I. e., for a circular ring the plates would be segments of a ring (arcs). For other ring shapes the plates would have to be adapted accordingly.

[0012] Not only the radiating plates, but also the shape of the ground plane should be adapted to the antenna's shape, e. g. a circular ring. The width of the ground plane should be similar to that of the plates. A slightly larger size will lead to a higher degree of focussing of the main radiation beam. The centre of the ring can be used for placement of components of the com-

munication device, i. e. it would encircle them.

[0013] The ground plane does not necessarily have to be ring-shaped. It is also possible to use - among others - a circular geometry. But the latter will lead to a less efficient use of space, as this configuration does not allow placing components in the centre of the antenna.

[0014] The separation between the radiating plates and the ground plane has mainly an impact on the bandwidth of the antenna. Generally, a larger separation yields a larger bandwidth. A separation of less than a tenth of the free-space wavelength at resonance should be observed. Otherwise higher order propagation modes will be excited which deteriorate radiation pattern and decrease antenna efficiency. It is also possible to place a dielectric between the plates and the ground plane. In this case the free-space wavelength does not apply any more. However, the wavelength in this medium should be used.

[0015] At resonance, the plates have a length slightly smaller than a quarter wavelength. The width of the plates should be only a fraction of the length. If a dielectric is to be used, the size is to be scaled accordingly.

[0016] For ring-shaped antennas that are relative small compared to the wavelength, the plates have to overlap each other, as shown in Figure 4. In this case, nearby plates are placed on opposite sides of the ground plane. An even number of plates results in an adequate implementation.

[0017] The feeding network is responsible for supplying an adequate signal to each plate. Changing the phase and amplitude controls the radiation pattern and polarisation of the antenna. For a linear polarised antenna, arbitrary combinations between phase and amplitude can be chosen, whereas for the case of circular polarisation the antenna elements should be fed in pairs with the same amplitude and a phase difference of 90° . The latter case requires an even number of radiators. In most cases it is difficult to achieve a good cross-polarisation discrimination in all radiation directions. But the quality of the radiation should be good enough for most applications in the area of miniaturised communication devices.

[0018] The feeding network used to generate the phase and amplitude relations for the radiators can be realised either as a distributed circuit or with lumped elements. The implementation as a distributed circuit has the advantage that it can be realised directly on or underneath the ground plane of the antenna, without having a major impact on the overall dimensions of the antenna (refer to Figure 5). The distributed circuit would consist of simple power splitters (T-shaped junctions), which can be realised e. g. as microstrip or coplanar waveguide structures. More complex circuits like e. g. hybrids or Wilkinson dividers would require too much space and are therefore impractical in most cases. The feeding network using lumped elements can be realised using inductors, capacitors or both.

[0019] The orientation and angle of the radiating edges

of the plates has a significant impact both on radiation pattern and antenna polarisation. This is specially the case when circular polarisation has to be achieved. In this case it is required that an even amount of radiating plates is fed in pairs, using the same signal amplitude but a phase difference of 90° between the two elements. In addition, the modes generated by each of the plate in this configuration in pairs have to be perpendicular. This can be done by placing to radiating elements face-to-face and having their radiating edges at an angle of approximately 90° (see Figure 6)

[0020] There is a large variety of ways how to implement the antenna. But only the most significant embodiments will be discussed in the following. The antenna can be realised as an air antenna, using no substrate between the ground plane and the radiating plates. The radiating plates themselves can be stamped or punched out of a metal sheet and bent afterwards. The plates do not necessarily have to be flat shapes that run parallel to the ground plane. Rounded structures are also possible. Each plate will have to be soldered on top of the ground plane. This can be easily done in an automated assembly and soldering process. For the ground plane and the feeding network a printed circuit board can be used. The substrate for this printed circuit has to be selected carefully. A high quality substrate based on e. g. PTFE or ceramic materials will yield low losses and therefore high antenna efficiency. The use of inexpensive substrates as e. g. FR4 will lead to higher loss due to the inadequate loss tangent and its non-homogeneous structure.

[0021] Another possible embodiment is to print the radiating plates, the ground plane and the feeding network on a multi-layer substrate. Using such a substrate for the antenna will yield a reduced size that will have to be traded for reduced radiation efficiency. Generally speaking, a lower dielectric constant leads to a higher efficiency and electrical bandwidth. As already mentioned before, care will have to be taken when selecting a certain type of substrate.

[0022] A very space efficient implementation of the antenna is to realise the radiating plates as a metallisation on the case or housing of the communication system. This is only possible the shape of the case is suitable. The ground plane and the feeding network can be realised using a printed circuit as described before. The connection between the case and the housing can be done using a spring contact

Claims

1. An antenna including a conductive ground plane, a number of independently radiating conductive plates and a feeding network;
2. The antenna as defined in claim 1 eventually including a dielectric substrate between the radiating

plates and the ground plane and / or between the feeding network and the ground plane;

3. The antenna as defined in claim 2 being embedded directly into the communication system; 5
4. The antenna as defined in claim 3 having a ring-shaped structure. This "ring" can be circular, elliptical, oval or even square among many other possible configurations; 10
5. The antenna as defined in claim 4 allowing placement of components used in the communication system in the centre of the antenna, therefore enclosing these by the ring structure; 15
6. The antenna as defined in claim 5 being able to define the shape and polarisation of the radiation pattern by means of changing the phase and amplitude with which the independent radiating plates are fed; 20
7. The antenna as defined in claim 6 using a feeding network to obtain the required phase and amplitude relations using either distributed or lumped elements; 25
8. The antenna as defined in claim 7 being able to define the shape and polarisation of the radiation pattern by means of changing the angles of the plates' radiating edges. 30

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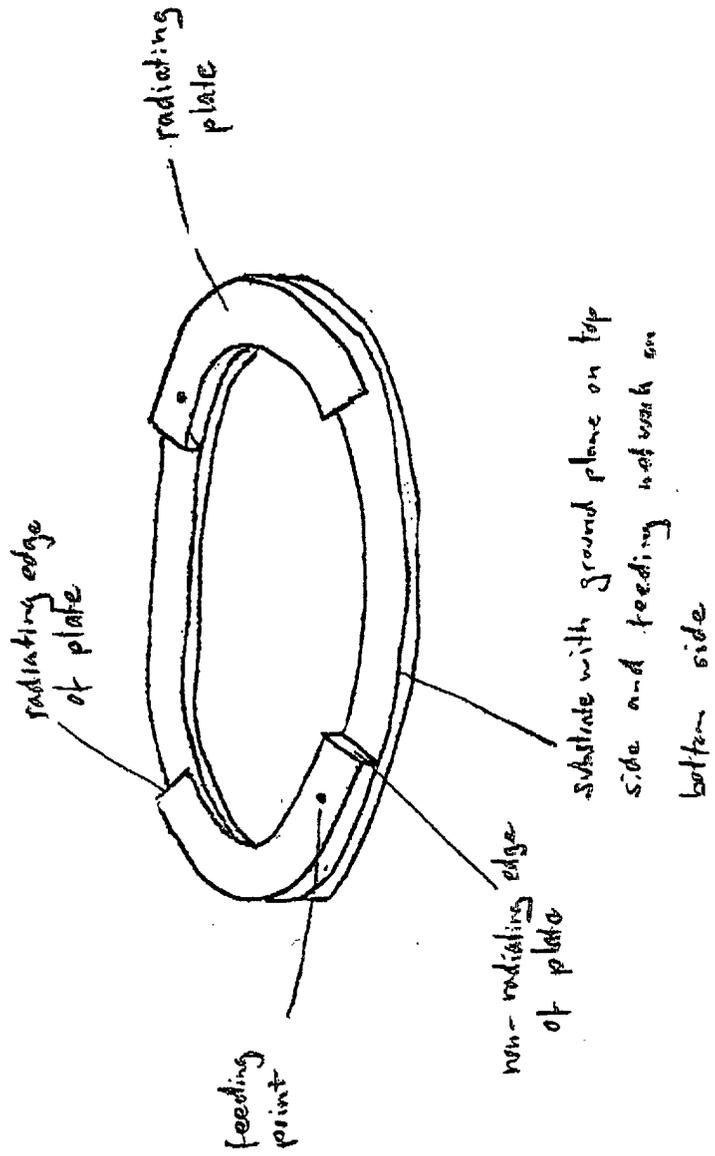


Figure 1

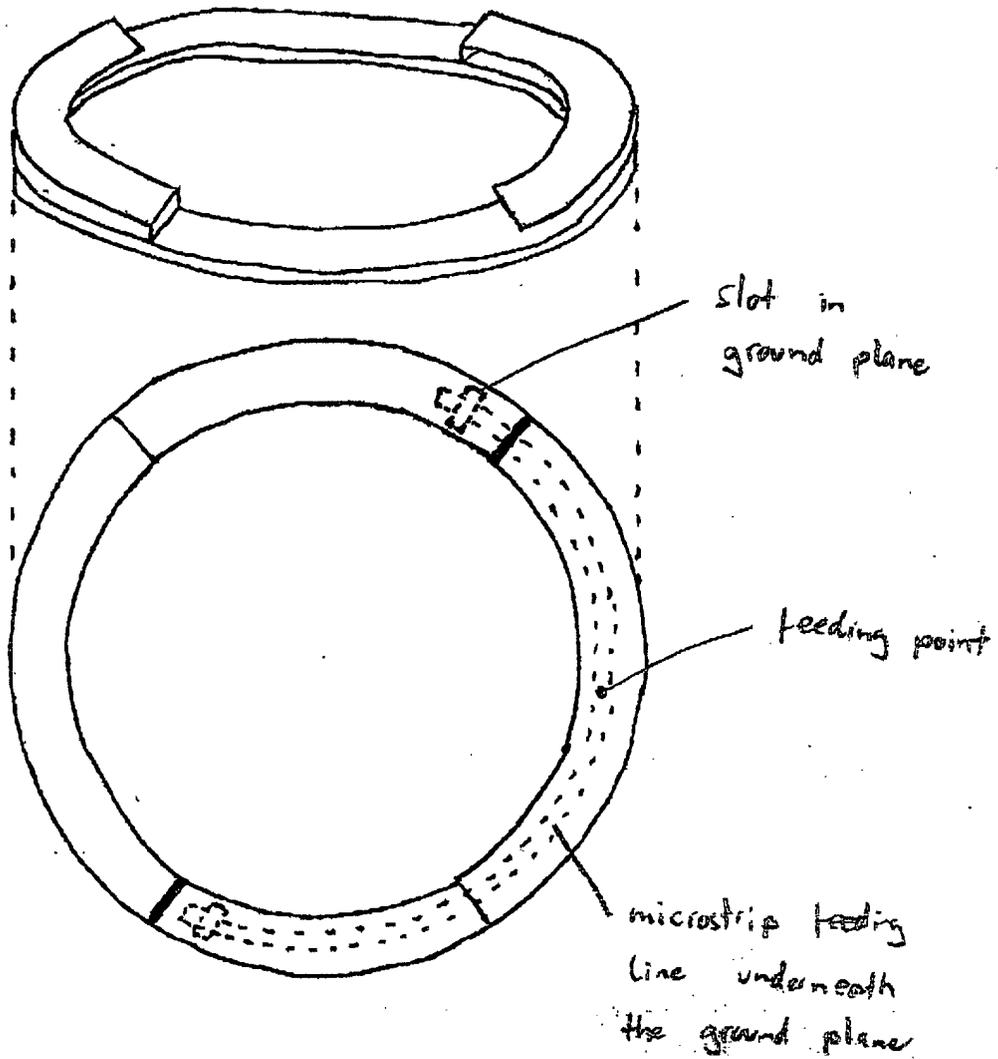
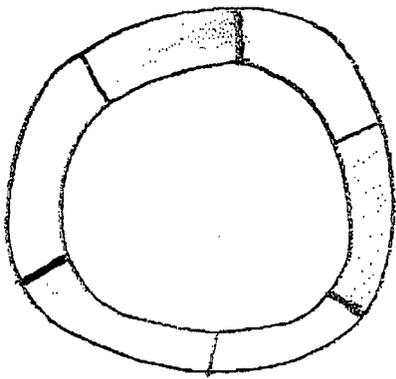
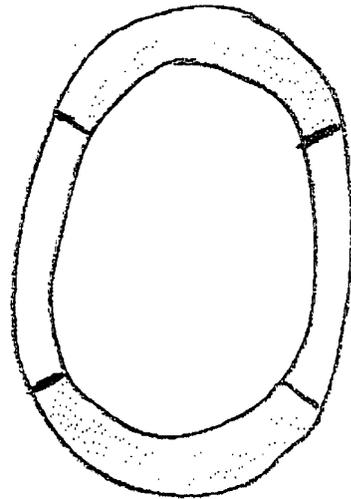


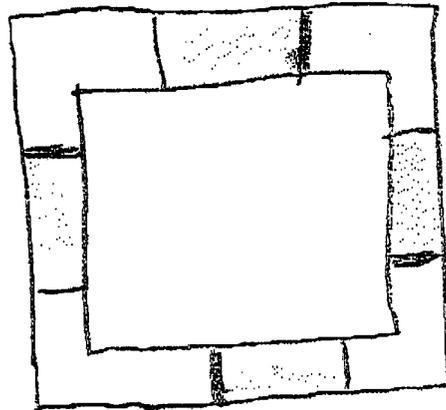
Figure 2



round shape



elliptical shape



square shape

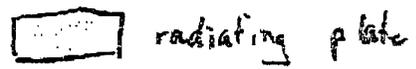


Figure 3

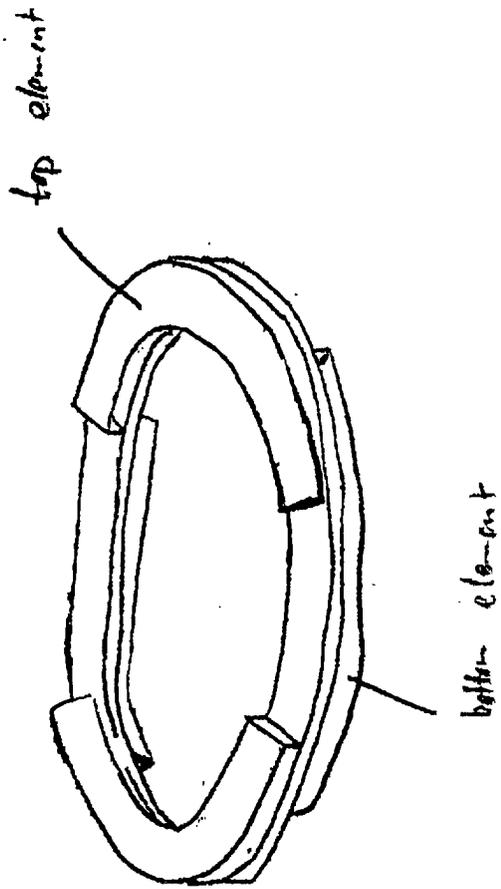


Figure 4

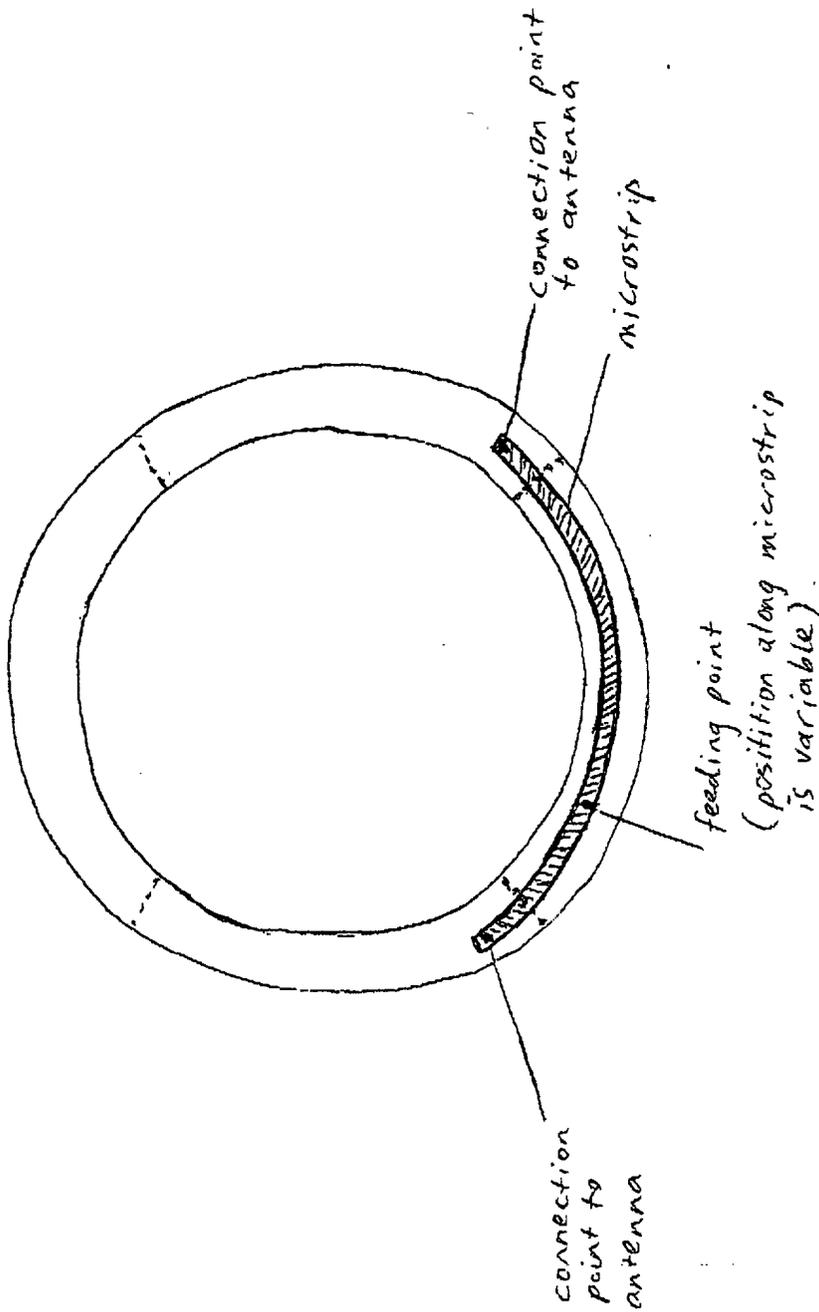


Figure 5



Figure 6



European Patent Office

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Application Number
EP 03 40 5120

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Y	* column 16, line 1 - column 17, line 47 * * figures 15-17 *	8	
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.7) H01Q
Place of search	Date of completion of the search	Examiner	
MUNICH	30 April 2003	Kruck, P	
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X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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