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(54) **SATELLITE ANTENNA USING A PLANAR REFLECTOR AND A MOVABLE FEEDARM AND METHOD TO OBTAIN A SUITABLE PLANAR REFLECTOR**

(57) An aspect of the invention concerns a satellite antenna (SA) comprising a planar reflector (PLA), a feedarm (FDA) attached to the planar reflector (PLA) by attaching means (AM); an antenna feed (ANF) attached to the feedarm (FDA) such as to receive the signal focused by the planar reflector (PLA). The planar reflector (PLA) comprises a continuous metallic layer acting as a ground plane and a plurality of conducting patches, said plurality of patches being designed so that the signal reflected by the planar reflector (PLA) is focused to a given focal region, and arranged in one or more layers, such layers being separated among them and from the ground plane by one or more other layers of insulating materials. Furthermore, the attaching means (AM) used to attach the feedarm (FDA) to the planar reflector (PLA) are arranged to allow the feedarm (FDA) to be moved independently from the planar reflector (PLA) so as to position the antenna feed (ANF) in the focused region of the reflected signal.

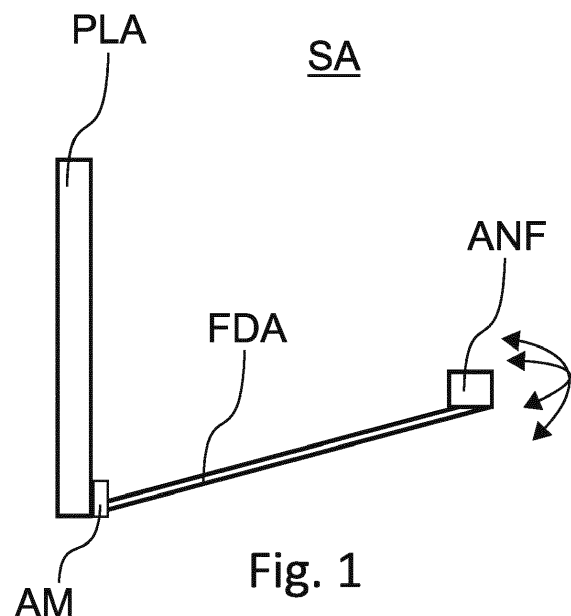


Fig. 1

Description

TECHNICAL FIELD

[0001] The invention is related to satellite antennas. More particularly the invention is related to a satellite antenna comprising a planar reflector focusing the signal in a given region and an antenna feed fixed on a feedarm, being positioned in the focusing region of the reflected signal by moving said feedarm only, and changing the antenna beam pointing direction.

BACKGROUND ART

[0002] Today's satellite antennas, when fixed to a wall or a roof, tend to protrude from them because they have to be oriented in order to properly receive the signal from a satellite. This has aesthetical consequences that may be important or sometimes unacceptable in case of historical buildings or of local regulations. Furthermore, this configuration makes satellite antennas more prone to damages induced by gusts of wind or snow falling from a roof which can move them or even pull them out. Such drawbacks have been in part mitigated by using planar (or flat) antenna arrays, but such planar antenna arrays are costly and present limitations such as high losses, reduced efficiency due to the use of beam forming networks, reduced size and consequently low gain, and do not allow multibeam operation.

[0003] Therefore, there is a need for antennas that have a reduced visual impact, and are more resistant to external conditions such as gusts of wind without having to rely on a beam forming network. The aim of the invention is to provide a solution to the problems just exposed.

DISCLOSURE OF THE INVENTION

[0004] The invention solves the above problems by proposing an antenna using a planar (or flat) reflector and a feed arm that can be moved independently from the planar reflector in order to ensure a proper signal reception. With such an antenna, the planar reflector can remain lying against a wall or a roof which make an antenna according to the invention integrated to the surface of the building, thus less visible and more resistant to gusts of wind.

[0005] A first aspect of the invention concerns a satellite antenna comprising a planar reflector, a feedarm attached to the planar reflector by attaching means and an antenna feed attached to the feedarm such as to receive the signal focused by the planar reflector. The planar reflector comprises a continuous metallic layer acting as a ground plane and a plurality of conducting patches, said plurality of patches being designed so that the signal reflected by the planar reflector is focused to a given region, and arranged in one or more layers, such layers being separated among them and from the ground plane by one or more layers of insulating materials. This type

of reflector is called a reflectarray. Furthermore, the attaching means used to attach the feedarm to the planar reflector are arranged to allow the feedarm to be moved independently from the planar reflector so as to position the antenna feed in the focusing region of the reflected signal from the selected satellite.

[0006] It should be noted that the planar reflector described here is not equivalent to a conventional planar antenna array without feed arm, already available on the market as satellite receiving antenna, which has an integrated beam forming network that collects the signal from the elements and delivers it to an integrated low-noise block converter. In the antenna according to the invention, as it has already been mentioned, the attaching means used to attach the feedarm to the reflector are arranged to allow the feedarm to be moved independently from the reflector so as to position the antenna feed in the focusing region of the reflected signal. This means that the planar reflector can remain lying on the wall or on the roof, the adjustments needed to properly receive the signal being made by moving the feedarm only. In addition to the several advantages already described, a satellite antenna according to the invention can be integrated in other facilities on a building, like solar panels for electricity or heat production.

[0007] In one embodiment, each patch of the plurality of patches has a shape and dimensions determined by the wavelength and by the required phase shift, to allow the focusing of the reflected signal in the direction of the antenna feed. Each patch has therefore potentially a different size and shape, since the required phase shift changes from one point to another of the planar reflector.

[0008] In one embodiment n azimuthal angle ranges and m elevation angle ranges are defined, each couple of ranges (j, k) where $j \in [1, n]$ et $k \in [1, m]$ being associated to a given patch (PT) configuration and the plurality of patches (PT) is configured according to one of the couple of ranges (j, k) .

[0009] Therefore, each configuration corresponds to a different design of the plurality of patches, and to a different direction (in azimuth and elevation) of the incoming wave. By making such a set of patches, it is possible to produce different orientations of the reflected signal, each orientation depending on the position of the antenna on Earth. Once the patch configuration is determined, the planar reflector can for instance be etched like a common printed circuit board, or printed taking advantage of the process of printing metalized patches to a plastic-based material. Once the planar reflector is in place, the fine settings can be made by moving the feedarm.

[0010] In one embodiment, the attaching means comprise an articulation with two degrees of freedom, for example a spherical swivel ball, said articulation attaching the feedarm to the planar reflector. As mentioned before, it allows the planar reflector to lay against the wall or the roof (and parallel to it) while the fine settings are done by moving the feedarm. In the case where several patch configurations are available for the planar reflector, and

having chosen the proper configuration given the elevation and azimuthal angle of the impinging signal, the feedarm has to be only appropriately moved to obtain a proper signal reception without the need to move the planar reflector.

[0011] In one embodiment, the antenna feed is attached to the feedarm using a second attaching means configured to allow a movement of the antenna feed along the feedarm.

[0012] In one embodiment, the antenna feed is attached to a low-noise block converter or a transmitting device.

[0013] A second aspect of the invention concerns a method for fabricating a planar reflector suitable to be mounted on an antenna according to the first aspect of the invention comprising:

- a step of determining at least one patch configuration based on geolocation information;
- a step of fabrication a planar reflector comprising a set of patches according to the determined configuration.

[0014] In one embodiment, the step of determining at least one patch configuration is performed for a plurality of predefined geographical regions on Earth so as to obtain a plurality of configurations, each configuration being associated with a geographical region on Earth and the step of fabrication is performed for one of the determined configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

- Figure 1 illustrates a satellite antenna according to one embodiment of the first aspect of the invention.
- Figures 2A and 2B illustrate two different examples of the cross section of the reflector according to one embodiment of the first aspect of the invention.
- Figure 3 illustrates a subset of the plurality of square patches according to one embodiment of the first aspect of the invention.
- Figure 4 illustrates other examples of patch shapes according to one embodiment of the first aspect of the invention.
- Figure 5A and 5B illustrate the different azimuthal ranges and the different elevation ranges according to one embodiment of the first aspect of the invention.
- Figure 6 illustrates the example of a spherical swivel ball in a satellite antenna according to one embodiment of the first aspect of the invention.
- Figure 7 illustrates a block diagram of a method according to one embodiment of the second aspect of the invention.

EMBODIMENTS OF THE INVENTION

[0016] In an embodiment illustrated in figures 1 and 2, the invention concerns a satellite antenna SA comprising an antenna feed ANF, a planar reflector PLA and a feedarm FDA attached to the planar reflector PLA by attaching means AM. The antenna feed ANF is attached to the feedarm FDA such as to receive the signal focused by the planar reflector PLA. In one embodiment, the antenna feed ANF is attached to a low-noise block converter or to a transmitting device.

[0017] As shown in figures 2, the planar reflector PLA comprises a continuous conducting layer GDP, for instance a continuous metallic layer, acting as a ground plane GDP. The planar reflector PLA further comprises a plurality of conducting patches PT, for instance metallic patches PT, said plurality of patches PT being designed so that the signal reflected by the planar reflector PLA is focused to a given region. In one embodiment illustrated in figure 2A, the patches PT of the plurality of patches PT are arranged in one layer. In another embodiment illustrated in figure 2B, the patches PT of the plurality of patches are arranged in at least two layers. Each layer of patches is separated from the next or previous one by one or more layers INS of insulating material. In the same way, the ground plane is separated from the closest layer of patches by one (as shown in figure 2A) or several (as shown in figure 2B) layers INS of insulating materials.

[0018] In one embodiment illustrated in figure 3, the plurality of patches PT is on a regular grid with mesh size DT, which is dependent on the wavelength. Each patch PT, whose center is located in the nodes of the grid, has a shape and dimensions WT determined by the wavelength and by the phase shift required for focusing the signal from each patch PT. More precisely, each patch PT causes a phase shift between the incident and the reflected waves, and they have globally the same effect as the reflection of a paraboloid. Therefore, appropriately modifying the configuration of the patches PT produces the same effect as orienting a standard parabolic reflector, but without moving the planar reflector PLA itself. Hence, for a given geographical position, and orientation of such a planar reflector PLA, and consequently knowing the azimuth and elevation directions of the desired satellite, it is possible to calculate the proper patch PT configuration that allows the signal to be focused to the antenna feed ANF. The fine adjustment also takes into account the orientation of the wall or roof and is obtained by moving the feedarm FDA and consequently the position of the antenna feed ANF.

[0019] In order to receive the reflected signal, the attaching means AM used to attach the feedarm FDA to the planar reflector PLA are arranged to allow the feedarm FDA to be moved independently from the planar reflector PLA so as to position the antenna feed ANF in the focused region of the reflected signal.

[0020] It can be more efficient to determine angular ranges in elevation and azimuth to obtain a first rough

orientation of the focused signal and then adjust the feedarm FDA to receive the signal properly. In one embodiment, n azimuthal angle ranges and m elevation angle ranges are defined, each couple of ranges (j,k) where $j \in [1,n]$ et $k \in [1,m]$ being associated with a given patch PT configuration. In the examples illustrated in figure 5A and 5B, three (3) azimuth and elevation ranges are defined: a first range of azimuthal angle between -50° and -20° , said A1; a second range of azimuthal angle between -20° and 20° , said A2; a third range of azimuthal angle between 20° and 50° , said A3. Furthermore three (3) elevation angle ranges are defined: a first range of elevation angle between 10° and 25° , said E1; a second range of elevation angle between 25° and 40° , said E2; a third range of elevation angle between 40° and 55° , said E3. Each couple of ranges (A_x, E_x) is then associated to a given patch configuration. Elevation angles on popular satellite positions vary depending on geographical positions; azimuth angles with respect to the mounting wall (or roof) vary depending on the orientation of the wall itself, but is generally limited to $\pm 45^\circ$, because the mounting wall should be the one whose normal is nearer to the satellite direction. With nine different combinations obtained, it is possible to consider all these variations. The nine configurations are chosen here as an example, and other ranges and number of ranges can be used depending on the needs. Thanks to those predefined set of patches, once the position of an antenna and its orientation is known, it is possible to choose the arrangement of patches adapted to the given location. In the example described above, it would thus require the fabrication of nine different models each with a given arrangement to accommodate all positions on Earth. The fine settings are then done by moving the feedarm FDA to ensure that the focused signal is optimally received by the antenna feed ANF. Furthermore, by determining those set of ranges, it is possible to limit the attaching means AM movements range to what is only needed for those set of ranges, for instance a spherical swivel ball.

[0021] In one embodiment, the attaching means AM comprise an articulation with two degrees of freedom. In one particular embodiment illustrated in figure 6, the attaching means AM comprise a spherical swivel ball SPS, said spherical swivel ball attaching the feedarm FDA to the planar reflector PLA. This spherical swivel ball SPS allows to move the feedarm FDA while the planar reflector PLA remains still and to position the antenna feed ANF in the focal region of said planar reflector PLA. In other words, a given patch arrangement gives a focal region that depends on the angle of the impinging signal. Having chosen the proper patch configuration given the elevation and azimuth angle of this impinging signal, the feedarm FDA has to be only moved of an appropriate amount to obtain a proper signal reception without the need to move the planar reflector PLA. Another way to see it, is to consider the configuration of the patches PT as a "virtual orientation" of the planar reflector PLA in the sense that it modifies the direction of focusing. Therefore, contrarily

to usual parabolic antennas, where the entire antenna has to be moved in order to obtain a good reception of the incoming signal, with a satellite antenna according to this invention only the feedarm FDA needs to be moved and the planar reflector PLA itself can remain lying against a wall or a roof. In one embodiment, in order to be able to further tune the antenna feed ANF position with respect to the planar reflector PLA, the antenna feed ANF is attached to the feedarm FDA using a second attaching means configured to allow a movement of the antenna feed ANF along the feedarm FDA.

[0022] An embodiment of the second aspect of the invention illustrated in figure 7 concerns a method for fabricating a planar reflector suitable to be mounted on an antenna according to the first aspect of the invention. The method comprises a step S1 of determining at least one patch configuration based on geolocation information. In one embodiment, the step S1 of determining the configuration is performed for a plurality of predefined geographical regions on Earth so as to obtain a plurality of configurations, each configuration being associated with a geographical region on Earth. For instance, n azimuthal angle ranges and m elevation angle ranges are defined, each couple of ranges (j,k) where $j \in [0,n]$ et $k \in [0,m]$ being associated with a given patch PT configuration.

[0023] The method used to compute the patch configuration in order to obtain a planar reflectarray is known from the person skilled in art. For instance, the reader can refer to J. Huang, J.A. Encinar, *Reflectarray Antennas*, IEEE Press, John Wiley & Sons, 2008 (in particular, chapter 4, 79-91) or J. Shaker, M.R. Chaharmir, J. Ethier, *Reflectarray Antennas: Analysis, Design, Fabrication, and Measurement*, Artech House, 2014 (in particular, chapter 2, pp 9-24), or P. Nayeri, F. Yang, A.F. Elsherbeni: "Reflectarray antennas: theory, designs and applications", IEEE Press, John Wiley & Sons, 2018, Chapt.2.

[0024] However, as a matter of illustration, the main steps of such a computation will be described here. First, some choices have to be made, some of them depending on the region on Earth for which the planar reflector is made for. More specifically, the method comprises a first step of choosing the frequency range, the size of the planar reflector, the value of F/D (also known as the focal ratio) and the feed characteristics. The method further comprises a second step of choosing the materials and the thickness of the insulating layers. The method further comprises a third step of choosing the element spacing of the planar reflector and consequently the number of patches and their position on the planar reflector surface. The method further comprises a fourth step of choosing the angular direction of the incident signal with respect to the planar reflector. Once those choices have been made, parameters of the planar reflector have to be determined. More precisely, the method further comprises, for each patch, a fifth step of computing the path difference to the direction of the incident signal, the corresponding phase difference at the central and extreme

frequencies and the range of phase shifts that each patch must provide to obtain the desired phase distribution for the focusing of the signal in the focusing region in the given frequency range. Once those parameters have been determined, the method further comprises a step of choosing an appropriate shape of each patch that may cover for varying frequency and dimensions the phase range derived in the previous step. Then the method further comprises a step of computing the phase curves for each patch for varying dimensions and frequency. Of course, the computing steps described in this method are usually performed using dedicated software known by the person skilled in the art and no further details will be given here for concision. The method further comprises a step of assigning to each patch the corresponding dimensions. Furthermore, it is recommended (but optional) to test the planar reflector obtained: in that case, the method further comprises a step of performing a full wave analysis of the designed structure for verification of the performances, and an optimization procedure to improve the performances, if necessary.

[0025] The method further comprises a step of fabrication of a planar reflector comprising a set of patches according to the determined configuration. The planar reflector PLA can for instance be etched like a common printed circuit board, or printed taking advantage of the process of printing metalized patches PT to a plastic-based material. In one embodiment, when several patch configurations are determined, the step of fabrication is performed for one of the determined configuration. In another embodiment, the step of fabrication is performed at least once for each configuration.

Claims

1. Satellite antenna (SA) comprising:

- a planar reflector (PLA) comprising:

- a continuous metallic layer acting as a ground plane;
- a plurality of conducting patches (PT), said plurality of patches (PT) being designed so that the signal reflected by the planar reflector (PLA) is focused to a given focal region, and arranged in one or more layers, such layers being separated among them and from the ground plane by one or more other layers of insulating materials;

- a feedarm (FDA) attached to the planar reflector (PLA) by attaching means (AM);
 - an antenna feed (ANF) attached to the feedarm (FDA) such as to receive the signal focused by the planar reflector (PLA) ;

the satellite antenna (SA) being characterized, the

attaching means (AM) used to attach the feedarm (FDA) to the planar reflector (PLA) are arranged to allow the feedarm (FDA) to be moved independently from the planar reflector (PLA) so as to position the antenna feed (ANF) in the focused region of the reflected signal.

2. Satellite antenna (SA) according to the preceding claim **characterized in that** each patch (PT) of the plurality of patches (PT) has a shape and dimensions determined by the length of the wave being focused by the planar reflector (PLA) and by the required phase shift to obtain the focusing of the impinging field in a given region.

3. Satellite antenna (SA) according to one of the preceding claims **characterized in that** n azimuthal angle ranges and m elevation angle ranges are defined, each couple of ranges (j,k) where $j \in [1,n]$ and $k \in [1,m]$ being associated with a given patch (PT) configuration, and that the plurality of patches (PT) is configured according to one of the couple of ranges (j,k) .

4. Satellite antenna (SA) according to one of the preceding claims **characterized in that** the attaching means (AM) comprise an articulation with two degrees of freedom.

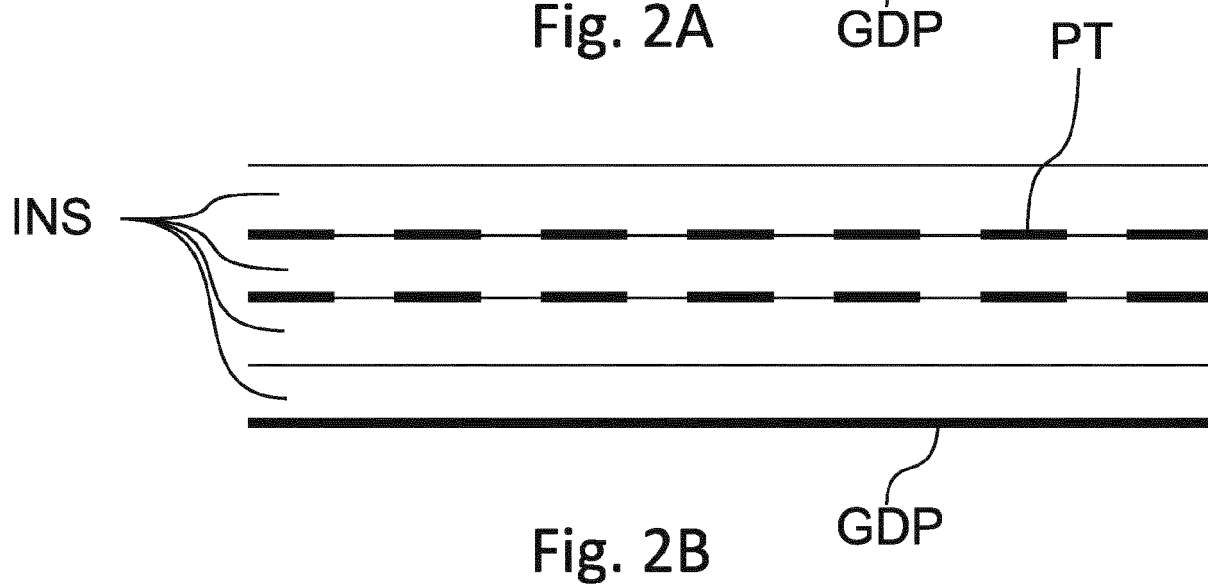
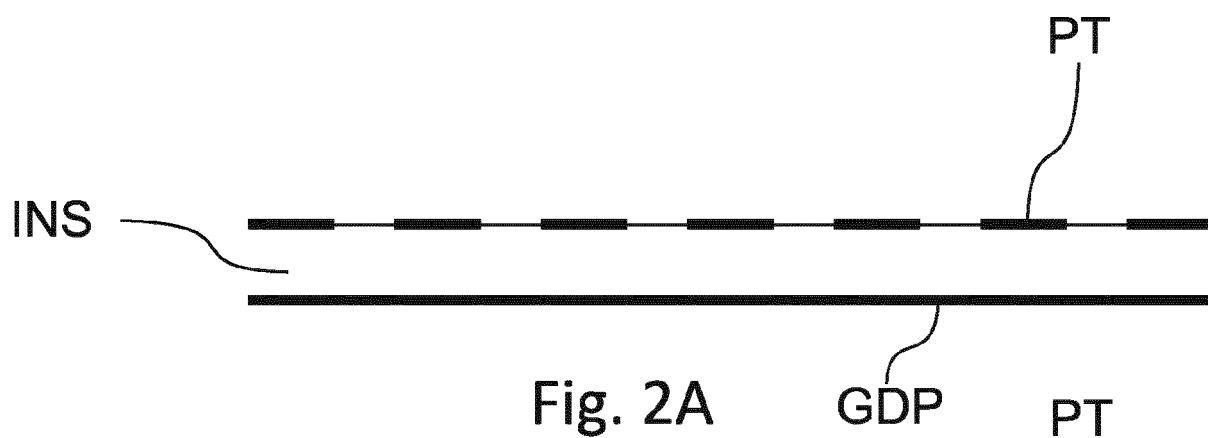
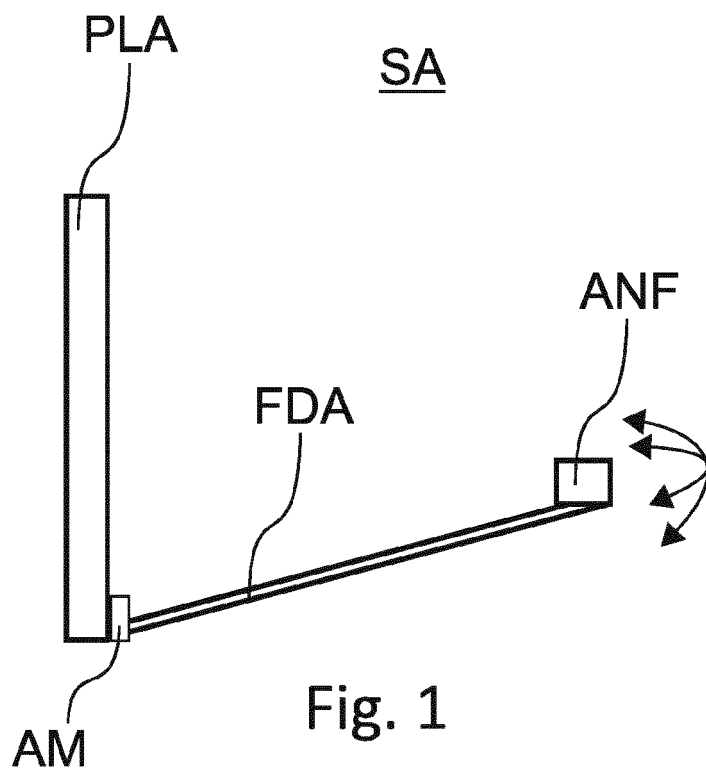
5. Satellite antenna (SA) according to one of the preceding claims **characterized in that** the antenna feed (ANF) is attached to the feedarm (FDA) using a second attaching means configured to allow a movement of the antenna feed (ANF) along the feedarm (FDA).

6. Method for fabricating a planar reflector suitable to be mounted on an antenna according to one of the preceding claims comprising:

- a step (S1) of determining at least one patch configuration based on geolocation information;
- a step (S2) of fabrication of a planar reflector comprising a set of patches according to the determined configuration.

7. Method according to the preceding claim in which the step(S1) of determining at least one patch configuration is performed for a plurality of predefined geographical regions on Earth so as to obtain a plurality of configurations, each configuration being associated with a geographical region on Earth and the step (S2) of fabrication is performed for one of the determined configuration.

8. Method according to the preceding claim in which the step (S2) of fabrication is performed at least once for each configuration.



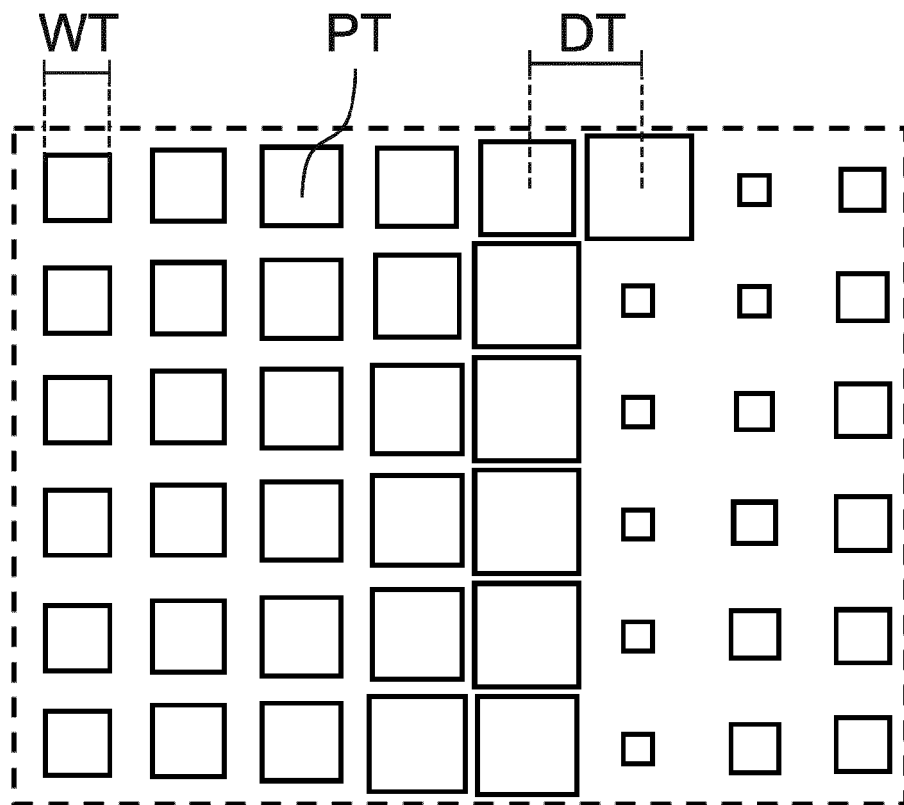


Fig. 3

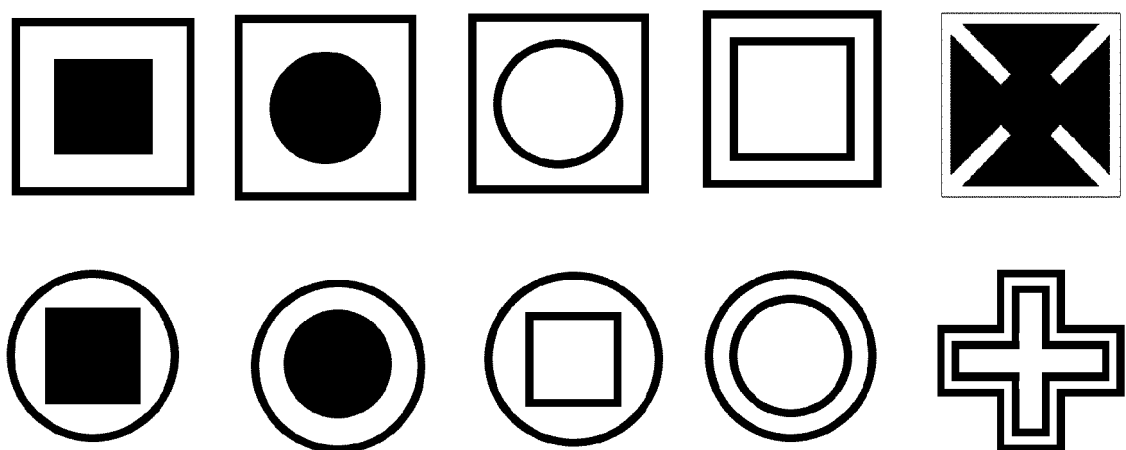


Fig. 4

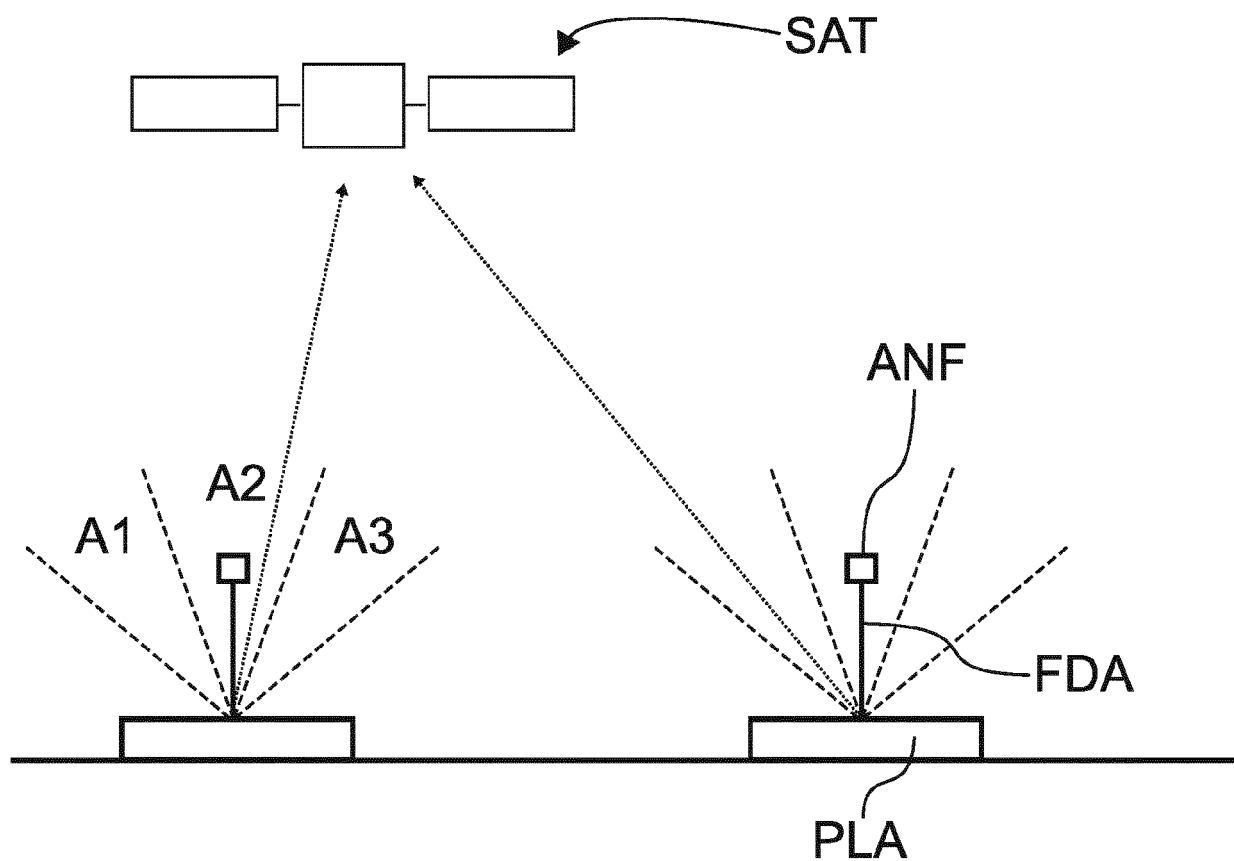


Fig. 5A

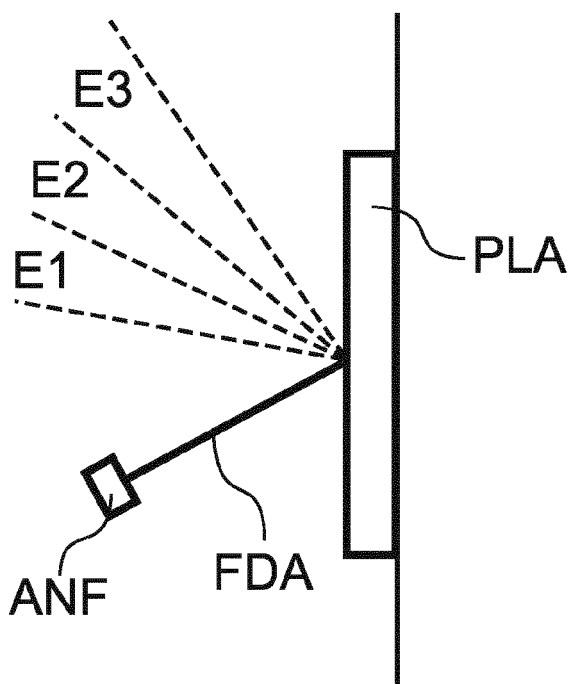


Fig. 5B

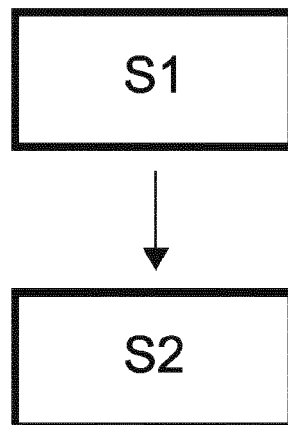
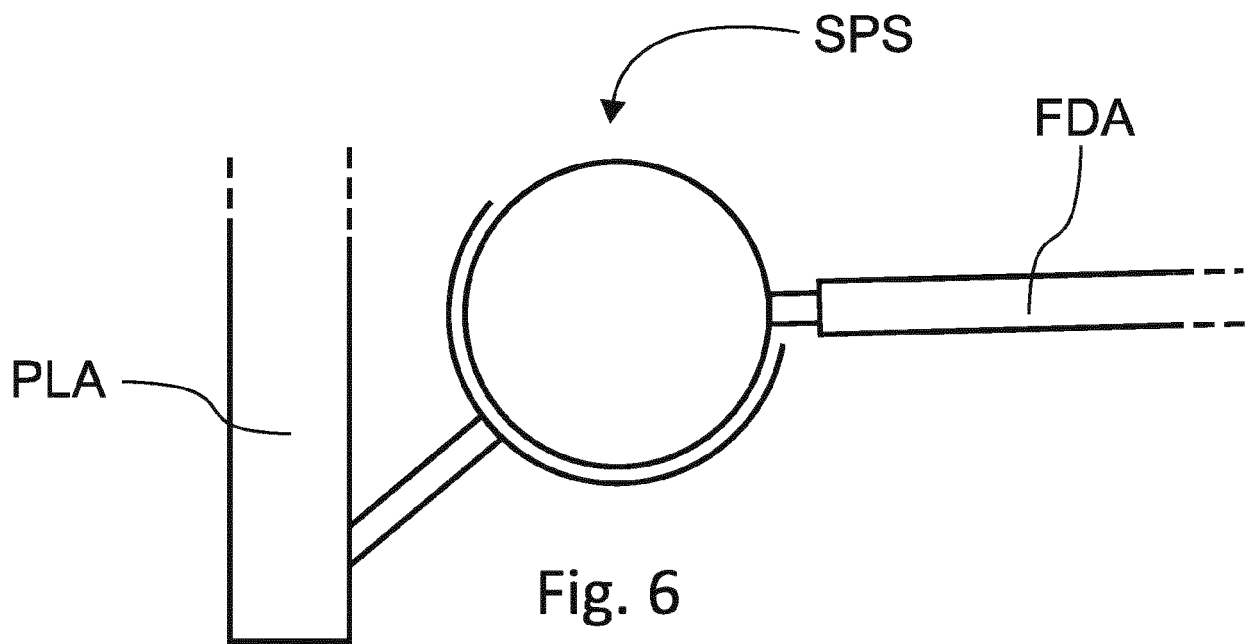


Fig. 7



EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2017/352952 A1 (WEILER RICHARD [DE] ET AL) 7 December 2017 (2017-12-07) * figures 1, 3A, 3B, 4 * * paragraph [0004] * * paragraph [0016] * * paragraph [0020] * * paragraph [0024] * * paragraph [0033] *	1,4	INV. H01Q3/18 H01Q19/10 H01Q15/00 H01Q3/46
X	WU GENG-BO ET AL: "Wide-Angle Beam-Scanning Reflectarray With Mechanical Steering", IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, IEEE SERVICE CENTER, PISCATAWAY, NJ, US, vol. 66, no. 1, 20 November 2017 (2017-11-20), pages 172-181, XP011675119, ISSN: 0018-926X, DOI: 10.1109/TAP.2017.2775282 [retrieved on 2017-12-27] * figures 1,10 * * figure 2 * * page 172 * * page 173, right-hand column, line 3 - line 10 * * page 177, left-hand column, line 1 - line 2 * * Section II * ----- -/--	1,2	TECHNICAL FIELDS SEARCHED (IPC) H01Q
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 26 April 2019	Examiner Kalialakis, Christos
CATEGORY OF CITED DOCUMENTS 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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EUROPEAN SEARCH REPORT

 Application Number
 EP 18 19 9167

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DOCUMENTS CONSIDERED TO BE RELEVANT				
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)	
X	US 2015/229032 A1 (LIU RUOPENG [CN] ET AL) 13 August 2015 (2015-08-13) * figures 22,25 * * paragraph [0005] * * paragraph [0017] - paragraph [0027] * * paragraph [0225] * * paragraph [0164] - paragraph [0165] * * paragraph [0270] - paragraph [0273] * * paragraph [0292] - paragraph [0293] * * paragraph [0306] * -----	1,3,6-8		
X	GUO LU ET AL: "Beam-scanning improvement of reflectarrays using single-layered sub-wavelength elements", 2015 IEEE 5TH ASIA-PACIFIC CONFERENCE ON SYNTHETIC APERTURE RADAR (APSAR), IEEE, 1 September 2015 (2015-09-01), pages 131-134, XP032799821, DOI: 10.1109/APSAR.2015.7306172 [retrieved on 2015-10-23] * figures 2a,2b * * Section III, 1st paragraph * -----	1		TECHNICAL FIELDS SEARCHED (IPC)
X	CN 102 683 855 A (KUANG CHI INNOVATIVE TECH CO) 19 September 2012 (2012-09-19) * figure 1 * * figure 11 * * figure 12 * * page 1, line 17 - line 18 * * page 7, line 4 - line 11 * -----	1,5		
The present search report has been drawn up for all claims				
Place of search The Hague		Date of completion of the search 26 April 2019	Examiner Kalialakis, Christos	
CATEGORY OF CITED DOCUMENTS 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				

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 19 9167

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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26-04-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017352952 A1	07-12-2017	CA 2977842 A1	01-09-2016
		CN 107431266 A	01-12-2017
		EP 3262712 A1	03-01-2018
		JP 2018507664 A	15-03-2018
		KR 20170110163 A	10-10-2017
		US 2017352952 A1	07-12-2017
		WO 2016134751 A1	01-09-2016

US 2015229032 A1	13-08-2015	EP 2919322 A1	16-09-2015
		US 2015229032 A1	13-08-2015
		WO 2014071866 A1	15-05-2014

CN 102683855 A	19-09-2012	NONE	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Non-patent literature cited in the description

- **J. HUANG ; J.A. ENCINAR.** Reflectarray Antennas. IEEE Press, John Wiley & Sons, 2008, 79-91 **[0023]**
- **J. SHAKER, M.R. CHAHARMIR ; J. ETHIER.** Reflectarray Antennas: Analysis, Design, Fabrication, and Measurement. Artech House, 2014, 9-24 **[0023]**
- **P. NAYERI ; F. YANG ; A.F. ELSHERBENI.** Reflectarray antennas: theory, designs and applications. IEEE Press, John Wiley & Sons, 2018 **[0023]**