

Compact antenna structure for satellite telecommunications

The present invention relates to an elementary antenna, a compact antenna structure for telecommunications comprising such an antenna, a platform comprising the antenna structure and a satellite communication method between two stations using the antenna structure.

In the field of satellite communications, obtaining a high-quality communication involves particular performance for the electromagnetic waves produced by the antenna structure used in the communication in terms of gain and secondary lobe level (ratio between the intensity of the secondary lobes and the intensity of the primary lobe). This is even more true for so-called "broadband" satellite communications, i.e., not emitting only voice.

In the particular case of the Ka electromagnetic band, two separate frequency bands are involved. In fact, in emitting, the electromagnetic waves of the Ka band have a frequency comprised between 27 gigahertz (GHz) and 31 GHz, while in receiving, the electric waves of the Ka band have a frequency comprised between 17.3 GHz and 21.2 GHz. In the rest of the description, the Ka band for emitting is denoted Tx, while the Ka band for receiving is denoted Rx. Furthermore, the polarizations of the emitting and receiving waves are generally of the circular type, and may or may not be opposite.

These frequencies and these circular polarizations in receiving and emitting impose constraints on the antenna structure. Furthermore, in the context of satellite connections, the antenna should be oriented so as to aim at the satellite making it possible to establish the connection. Furthermore, to reduce the visual signature (physical bulk), parabolic antenna-type solutions are generally not favored. This is particularly true given that in that case, the depth of the antenna is constrained by the focal distance of the source illuminating the satellite dish.

Among the antenna structures making it possible to respect these various constraints, it is known to use an electronically-scanned antenna for the emitting of a wave whose central frequency is around 30 GHz and for the receiving of a wave centered around 20 GHz.

However, the electronically-scanned antenna obtained may have a significant bulk corresponding to the radiating surfaces of each of the operating modes (emitting/receiving). Furthermore, the efficiency of such an antenna may be insufficient based on the elementary antenna used and the associated power circuit, in particular when patch-type antennas are involved.

Furthermore, the implementation of a circular polarization in a first direction in the emitting part and a circular polarization in a second direction that may or may not be opposite the first direction for the receiving part proves difficult if a polarizer is used, which reduces the usage flexibility of the considered scanning antenna.

There is therefore a need for an antenna structure for telecommunications, in particular satellite in the Ka band, having a reduced bulk in terms of depth and aiming capacity while using an electronic scanning principle while also making it possible to obtain a good quality communication, in particular in terms of gain, axial ratio and secondary lobes compatible with normative templates.

To that end, an antenna structure for telecommunications is proposed, in particular by satellite, comprising an emitting surface comprising at least one set of a plurality of elementary emitting antennas forming an array, at least one elementary emitting antenna comprising two generally circular patches that are at least partially superimposed, said at least one elementary emitting antenna being dimensioned to emit at least one electromagnetic wave having a frequency comprised between 27 gigahertz (GHz) and 31 GHz. The antenna structure also comprises a receiving surface comprising at least one set of a plurality of elementary receiving antennas forming an array, at least one elementary receiving antenna comprising two generally circular patches that are at least partially superimposed, said at least one elementary receiving antenna being dimensioned to receive at least one electromagnetic wave having a frequency comprised between 17.3 GHz and 21.2 GHz.

According to specific embodiments, the antenna structure comprises one or more of the following features considered alone or according to all technically possible combinations:

- each patch of said at least one elementary emitting antenna has a center, said elementary emitting antenna comprising two power supply ports able to power one of the two patches, each port being in an angular sector having an angle relative to the center of the powered patch smaller than 180° , and/or each patch of said at least one elementary receiving antenna has a center, said elementary receiving antenna comprising two power supply ports able to power one of the two patches, each port being in an angular sector having an angle relative to the center of the powered patch smaller than 180° .

- the two patches of said at least one elementary emitting antenna are spaced apart in a first direction by a distance comprised between 0.5 millimeters (mm) and 2.0 mm, and/or the two patches of said at least one elementary receiving antenna are spaced apart in a first direction by a distance comprised between 0.5 millimeters (mm) and 2.0 mm.

- the two patches of said at least one elementary emitting antenna are spaced apart in a first direction by a distance comprised between 0.75 millimeters (mm) and 1.5 mm, and/or the two patches of said at least one elementary receiving antenna are spaced apart in a first direction by a distance comprised between 0.75 millimeters (mm) and 1.5 mm.

- the diameters of the two patches of said at least one elementary emitting antenna are identical, and/or the diameters of the two patches of said at least one elementary receiving antenna are identical.

- the elementary emitting antennas of the antenna structure all comprise two generally circular patches that are at least partially superimposed, each elementary emitting antenna being dimensioned to emit at least one electromagnetic wave having a frequency comprised between 27 GHz and 31 GHz, and/or the elementary receiving antennas of the antenna structure all comprise two generally circular patches that are at least partially superimposed, each elementary receiving antenna being dimensioned to receive at least one electromagnetic wave having a frequency comprised between 17.3 GHz and 21.2 GHz.

- the elementary emitting antennas and the elementary receiving antennas are arranged in staggered rows.

- the emitting surface is generally rectangular and comprises at least two sets of a plurality of elementary emitting antennas each forming an array, the elementary emitting antennas of each set being along a line specific to that set, each line being parallel to the other specific lines, and/or the receiving surface is generally rectangular and comprises at least two sets of a plurality of elementary receiving antennas each forming an array, the elementary receiving antennas of each set being along a line specific to that set, each line being parallel to the other specific lines.

Furthermore, the invention also relates to a platform, in particular aerial, comprising at least one antenna structure as previously described.

The present invention also relates to a telecommunications method, in particular by satellite, between two stations comprising at least one of the following steps: a step for emitting electromagnetic waves having a frequency comprised between 27 GHz and 31 GHz by an antenna structure as previously described, and a step for receiving electromagnetic waves having a frequency comprised between 17.3 GHz and 21.2 GHz by an antenna structure as previously described.

Other features and advantages of the invention will appear upon reading the following detailed description of embodiments of the invention, provided solely as an example and in reference to the drawings:

- figure 1 is a diagram of an antenna structure able to work on the Ka band,
- figure 2 is a perspective diagram of an elementary antenna working on the Tx band,
- 5 - figures 3 and 4 are graphs respectively showing the evolution of the axial ratio and the stationary wave ratio of the elementary antenna of figure 2 on the Tx band as a function of the operating frequency,
- figure 5 is a diagram of an array comprising a set of elementary antennas according to figure 2,
- 10 - figures 6 and 7 are graphs showing the evolution of the axial ratio and the stationary wave ratio of the array of figure 5 as a function of the operating frequency,
- figure 8 is a graph showing the evolution of the gain of the antenna structure according to figure 5 as a function of the elevation angle,
- figure 9 is a diagram of a panel working on the Tx band and comprising arrays according to figure 5;
- 15 - figures 10 and 11 are graphs showing the evolution of the gain of the panel of figure 9 as a function of the elevation angle and for a given azimuth angle,
- figure 12 is a graph showing the evolution of the axial ratio of the panel of figure 9 as a function of the operating frequency,
- 20 - figure 13 is a graph showing the evolution of the gain of the panel of figure 9 as a function of the azimuth angle when a misalignment is implemented,
- figure 14 is a perspective diagram of an elementary antenna operating on the Rx band,
- figures 15 and 16 are graphs showing the evolution of the axial ratio and the stationary wave ratio for the elementary antenna of figure 14 on the Rx band as a function of the operating frequency,
- 25 - figure 17 is a diagram of an array comprising a set of elementary antennas according to figure 14,
- figures 18 and 19 are graphs showing the evolution of the axial ratio and the stationary wave ratio of the array of figure 17 as a function of the operating frequency,
- 30 - figure 20 is a graph showing the evolution of the gain of the array of figure 17 as a function of the elevation angle,
- figure 21 is a diagram of a panel working on the Rx band and comprising arrays according to figure 17;
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- figures 22 and 23 are graphs showing the evolution of the gain of the panel of figure 21 as a function of the elevation angle and the azimuth angle, respectively, and
- figure 24 is a graph showing the evolution of the axial ratio of the panel of figure 21 as a function of the operating frequency.

In the context of an application in telecommunications, in particular by satellite in the Ka band, an antenna structure 10 is proposed comprising an emitting surface 11Tx and a receiving surface 11Rx as shown in figure 1.

In the illustrated example, the emitting surface 11Tx has a generally rectangular shape and the receiving surface 11Rx also has a generally rectangular shape. Each emitting 11Tx and receiving 11Rx surface receives a plurality of elementary antennas 12Tx (for emitting) and 12Rx (for receiving).

The assembly of the emitting surface 11Tx and the plurality of elementary antennas 12Tx forms an emitting panel 13Tx, while the assembly of the receiving surface 11Rx and the plurality of elementary antennas 12Rx forms a receiving panel 13Rx.

Hereinafter, the structure of the emitting panel 13Tx is outlined by successively describing an elementary antenna 12Tx for emitting (figures 2 to 4), a line comprising a plurality of elementary antennas 12Tx for emitting (figures 5 to 8), then the emitting panel 13Tx itself (figures 9 to 13). An elementary antenna 12Tx for emitting is shown in figure 2. This means that the elementary antenna 12Tx is able to emit an electromagnetic wave whereof the wavelength is denoted λ_0 , that wavelength λ_0 corresponding to a central frequency of the band comprised between 27 GHz and 31 GHz.

The elementary antenna 12Tx comprises two patches 14Tx, 16Tx that are at least partially superimposed.

Each patch 14Tx, 16Tx has a circular shape.

The first patch 14Tx comprises a first metallized layer 18Tx and a first insulating layer 20Tx, the first metallized layer 18Tx being arranged on the insulating layer 20Tx.

The first metallized layer 18Tx is therefore circular and has a first diameter d_{1Tx} .

The shape of the first metallized layer 18Tx gives the first patch 14Tx a circular shape.

The second patch 16Tx also comprises a second metallized layer 22Tx and a second insulating layer 24Tx, the second metallized layer 22Tx being arranged on the second insulating layer 24Tx.

The second metallized layer 22Tx comprises a circular part 26Tx and two ports 28Tx, 30Tx for supplying current.

The circular part 26Tx has a circular shape and has a second diameter denoted d_{2Tx} . The first port 28Tx comprises two first segments 32Tx and 34Tx, a first proximal segment 32Tx in contact with the circular part 26Tx and a first distal segment 34Tx relative to the circular part 26Tx.

5 The first proximal segment 32Tx is rectilinear and extends in a direction called first proximal direction. The first proximal segment 32Tx is normal relative to the portion of the circular part 26Tx with which the first proximal segment 32Tx is in contact.

10 The first distal segment 34Tx is rectilinear and extends in the extension of the proximal segment 32Tx in a direction called first distal direction. The first proximal and distal directions form an angle greater than 90° between them. Preferably, the angle between the first proximal direction and the first distal direction is comprised between 120° and 145° .

15 Likewise, the second port 30Tx comprises two second segments 38Tx and 40Tx, a second proximal segment 38Tx in contact with the circular part 26Tx and a second distal segment 40Tx relative to the circular part 26Tx.

The second proximal segment 38Tx is rectilinear and extends in a direction called second proximal direction. The second proximal segment 38Tx is normal relative to the portion of the circular part 26Tx with which the second proximal segment 38Tx is in contact.

20 According to the example of figure 2, the two proximal directions form an angle smaller than 180° between them. Thus, each port 28Tx, 30Tx is in an angular sector having an angle relative to the center of the circular part smaller than 180° .

25 In other words, the distance between the two ports 28Tx and 30Tx is smaller than $0.5 \cdot \lambda_0$ to make it possible to perform the aiming function by phase shift with the smallest possible deterioration of the secondary lobes in order to remain compatible with normalization templates. Preferably, the distance between the two ports 28Tx and 30Tx is smaller than or equal to $0.42 \cdot \lambda_0$.

30 The second distal segment 40Tx is rectilinear and extends in the extension of the second proximal segment 38Tx in a direction called second distal direction. The second proximal and distal directions form an angle greater than 90° between them. Preferably, the angle between the second proximal direction and the second distal direction is comprised between 120° and 145° .

35 The shape of the second metallized layer 22Tx gives the second patch 16Tx a generally circular shape such that it is considered, in a simplified manner hereinafter, that the second patch 16Tx has a circular shape.

Thus, it is in particular considered that the second diameter d_{2Tx} of the circular part 26Tx is the diameter of the second patch 16Tx.

Preferably, the first diameter d_{1Tx} and the second diameter d_{2Tx} can be identical.

The two patches 14Tx and 16Tx are at least partially superimposed. This means that the two patches 14Tx and 16Tx are at least partially aligned in a first direction Z.

According to the particular example of figure 2, two patches 14Tx and 16Tx are superimposed. This means that the projection of the circular part 26Tx on the plane comprising the first metallized layer 18Tx is combined with the first metallized layer 18Tx.

Furthermore, the circular part 26Tx and the first metallized layer 18Tx are parallel. The two patches 14Tx and 16Tx are thus spaced apart in a first direction Z by a distance denoted e_{zTx} .

Preferably, the spacing distance e_{zTx} between the two patches 14Tx and 16Tx in the first direction Z is comprised between 0.5 millimeters (mm) and 2.0 mm. Advantageously, the spacing distance e_{zTx} between the two patches 14Tx and 16Tx in the first direction Z is comprised between 0.75 mm and 1.5 mm.

In a manner known in itself, the spacing distance e_{zTx} between the two patches 14Tx and 16Tx in the first direction Z, the diameter d_{1Tx} and d_{2Tx} of the patches 14Tx and 16Tx make it possible to determine the frequency or frequencies at which the elementary antenna 12Tx can emit.

The elementary antenna 12Tx is dimensioned to emit frequencies comprised between 27 GHz and 31 GHz (Tx band). This means that such an elementary antenna 12Tx has first and second diameters d_{1Tx} , d_{2Tx} comprised between 2.5 mm and 4 mm. The upper bound corresponds to the product of 0.4 by the wavelength λ_0 that the elementary antenna 12Tx is capable of emitting.

Alternatively, instead of a condition on the diameters d_{1Tx} , d_{2Tx} , a constraint is imposed on the geometry of the second patch 16Tx. The second patch 16Tx can be fitted into a rectangle whereof the extension e_{xTx} in a second direction X is comprised between 4.0 mm and 4.4 mm, and the extension e_{yTx} in a third direction Y is comprised between 3.8 mm and 4.2 mm. The two directions X and Y are perpendicular to each other and to the first direction Z.

The performance of the elementary emitting antenna 12Tx will now be described in reference to figures 3 and 4.

Figures 3 and 4 show that over the entire band of interest (in this case, the Tx band), the axial ratio and the stationary wave ratio (denoted using the corresponding acronym, SWR, in all of the figures in which this ratio appears for simplification purposes) are relatively low.

The elementary antenna 12Tx therefore has a wide band, i.e., a band 5% wider around the central operating frequency, with circular polarization and a very good efficiency of illumination (in particular the axial ratio for such a small antenna is better than in the state of the art and the apodization of the radiation pattern for the emitted wave is facilitated during networking).

It should be noted that in the illustrated embodiment, the two patches 14Tx and 16Tx are arranged such that the second metallic layer 22Tx faces the first insulating layer 20Tx.

Alternatively, the two patches 14Tx and 16Tx are arranged such that the second metallic layer 22Tx faces the first metallic layer 18Tx.

An array 50Tx has also been proposed as illustrated by figure 5, comprising a plurality of elementary antenna 12Tx for emitting.

According to the particular example of figure 5, the array 50Tx comprises twenty-four elementary antennas 12Tx.

In general, a combination of a larger number of elementary antennas 12Tx is possible based on the overall dimensions and desired performance, in particular in terms of the gain of the array 50Tx.

Each elementary antenna 12Tx of figure 5 is identical to the elementary antenna 12Tx described in reference to figure 2.

Alternatively, some antennas are different.

The elementary antennas 12Tx are arranged regularly along a line thus forming the array 50Tx. Furthermore, the elementary antennas 12Tx are connected to each other to form the array 50Tx. The connection is done by means of two rectilinear lines that ensure the power supply of the unit array. The array 50Tx thus formed for emitting has two ports that make it possible, based on the power supply, to radiate an electromagnetic wave in the desired frequency band using the desired circular polarization.

In the example of figure 5, the array 50Tx has an extension ex2Tx along the second direction X comprised between 4 mm and 6 mm. Preferably, the extension ex2Tx in the second direction X is comprised between 4.5 mm and 5.5 mm.

In the example of figure 5, the array 50Tx also has an extension ey2Tx in the third direction Y comprised between 160 mm and 190 mm. Preferably, the extension ey2Tx in the third direction Y is comprised between 165 mm and 185 mm.

During operation, each elementary antenna 12Tx of the array 50Tx is powered by an electromagnetic wave. Each elementary antenna 12Tx captures the electrical field coming from electromagnetic wave so that the array 50Tx emits a wave in the desired frequency band.

The performance in terms of axial ratio and stationary wave ratio and advantages imparted by the array 50Tx are similar to the performance and advantages imparted by the elementary antennas 12Tx of figure 2 as shown by studying figures 6 and 7.

Furthermore, figure 8 shows that the array 50Tx has a gain of approximately 20 dB, which attests to the good efficiency of illumination of the antenna structure in light of its dimensions, i.e., the extension $ex2Tx$ in the second direction X and the extension $ey2Tx$ in the third direction Y.

Figure 9 illustrates the emitting panel 13Tx of figure 1. The elements identical to the embodiment of figure 5 are not described again. Only the differences are shown.

The emitting panel 13Tx comprises eight arrays 50Tx instead of a single array 50Tx.

In general, a combination of a larger number of arrays 50Tx is possible based on the overall dimensions and desired performance in particular in terms of gain and radiation opening.

In the case at hand, the number of antennas for the array 50Tx is chosen as a function of a dimensional constraint applied in the third direction Y.

Each array 50Tx is parallel to the other arrays 50Tx.

The elementary antennas 12Tx are arranged in staggered rows. Such an arrangement makes it possible to preserve the performance in terms of stability of the axial ratio during networking of the overall structure as well as during aiming by phase shift.

Furthermore, in the example of figure 9, the emitting panel 13Tx has an extension $ex3Tx$ in the second direction X comprised between 40 mm and 50 mm. Preferably, the extension $ex3Tx$ in the second direction X is comprised between 45 mm and 48 mm. The extension $ex3Tx$ in the second direction X is connected to the number of array antennas 50Tx in question. In the case shown in figure 9, the extension $ex3Tx$ in the second direction X corresponds to approximately nine times the size of an elementary antenna.

In the example of figure 9, the emitting panel 13Tx also has an extension $ey3Tx$ in the third direction Y comprised between 160 mm and 190 mm. Preferably, the extension $ey3Tx$ in the third direction Y is comprised between 165 mm and 185 mm. The extension $ey3Tx$ in the third direction Y is related to the number of elementary antennas 12Tx in question.

The performance in terms of axial ratio and advantages imparted by the emitting panel 13Tx are similar to the performance and advantages imparted by the elementary antenna 12Tx of figure 2, as shown by studying figure 12.

Furthermore, figures 10 and 11 show that the emitting panel 13Tx has a gain of approximately 28 dB, which corresponds to an efficient compact antenna structure at the considered operating frequency.

Furthermore, when a misalignment is done, it can be shown by comparing figures 11 and 13 in particular that the gain of 26 dB is obtained in a relatively remote direction determined by an azimuth angle of 30°. The proposed emitting panel 13Tx is therefore robust with respect to misalignment with a very low rise of the secondary lobes.

Below, the structure of the receiving panel 13Rx of figure 1 is outlined by successively describing an elementary antenna 12Rx for receiving (figures 14 to 16), a line comprising a plurality of elementary antennas 12Rx for receiving (figures 17 to 20), then the receiving panel 13Rx itself (figures 21 to 24).

Figure 14 illustrates an elementary antenna 12Rx for receiving. The elements identical to the elementary emitting antenna 12Tx of figure 2 are not described again. Only the differences are shown.

The reference signs of the elements of the elementary receiving antenna 12Rx are followed by an Rx suffix instead of the Tx suffix for the corresponding elements of the elementary antenna 12Rx.

An elementary antenna 12Rx for receiving is shown in figure 14. This means that the elementary antenna 12Rx is able to receive an electromagnetic wave whose wavelength is denoted λ_0 , that wavelength λ_0 corresponding to a frequency comprised between 17.3 GHz and 21.2 GHz.

Consequently, the elementary antenna 12Rx is dimensioned to receive frequencies comprised between 17.3 GHz and 21.2 GHz (Rx band). This means that such an elementary antenna 12Rx has first and second diameters d_{1Rx} , d_{2Rx} comprised between 4.5 mm and 7 mm.

Alternatively, instead of a condition on the diameters d_{1Rx} , d_{2Rx} , a constraint is imposed on the second patch 16Rx. The second patch 16Rx can then be fitted into a rectangle whereof the extension e_{xRx} in the second direction X is comprised between 6.6 mm and 7.0 mm and the extension e_{yRx} in the third direction Y is comprised between 6.0 mm and 6.4 mm.

The receiving performance of the elementary antenna 12Rx will now be described in reference to figures 15 and 16.

The performance and advantages imparted by the elementary receiving antenna 12Rx are similar to the performance and advantages imparted by the elementary emitting antenna 12Tx, as shown by studying figures 15 and 16.

Figure 17 illustrates an array 50Rx for receiving according to the invention. According to the specific example of figure 17, the array 50Rx comprises eighteen elementary antennas 12Rx.

In general, a combination of a larger number of elementary antennas 12Rx is possible based on the overall dimensions and desired performance, in particular in terms of the gain of the array 50Rx.

In the case at hand, the number of antennas for the array 50Rx is chosen as a function of a dimensional constraint applied in the third direction Y.

Each elementary antenna 12Rx of figure 17 is identical to the elementary antenna 12Rx described in reference to figure 14.

Alternatively, some antennas are different.

The elementary antennas 12Rx are arranged regularly along a line thus forming the array 50Rx. Furthermore, the elementary antennas 12Rx are connected to each other to form the array 50Rx. The connection is done by means of a rectilinear line that ensures the power supply of the unit array. The array 50Rx thus formed for receiving has two ports that make it possible, based on the power supply, to receive an electromagnetic wave in the desired frequency band using the desired circular polarization.

In the example of figure 17, the array 50Rx has an extension ex2Rx in the second direction X comprised between 6 mm and 8.5 mm. Preferably, the extension ex2Rx in the second direction X is comprised between 7.6 mm and 8.0 mm.

In the example of figure 17, the array 50Rx also has an extension ey2Rx in the third direction Y comprised between 180 mm and 200 mm. Preferably, the extension ey2Rx in the third direction Y is comprised between 185 mm and 195 mm. The extension ey2Rx in the third direction Y is related to the number of elementary antennas 12Rx in question.

The performance in terms of axial ratio and stationary wave ratio and advantages imparted by the array 50Rx are similar to the performance and advantages imparted by the elementary antennas 12Rx according to the example of figure 14 as shown by studying figures 18 and 19.

Furthermore, figure 20 shows that the array 50Rx has a gain of approximately 18 dB, which corresponds to an efficient compact antenna structure at the considered operating frequency.

Figure 21 illustrates the receiving panel 13Rx of figure 1. The elements identical to the embodiment of figure 17 are not described again. Only the differences are shown.

The receiving panel 13Rx comprises eight arrays 50Rx instead of a single array 50Rx.

In general, a combination of a larger number of arrays 50Rx is possible based on the overall dimensions and desired performance in particular in terms of gain and radiation opening.

Each array 50Rx is parallel to the other arrays 50Rx.

5 The elementary antennas 12Rx are arranged in staggered rows. Such an arrangement makes it possible to preserve the performance in terms of stability of the axial ratio during networking of the overall structure as well as aiming by phase shift.

Furthermore, in the example of figure 21, the receiving panel 13Rx has an extension ex3Rx in the second direction X comprised between 60 mm and 80 mm. 10 Preferably, the extension ex3Rx in the second direction X is comprised between 65 mm and 75 mm. The extension ex3Rx in the second direction X is related to the number of arrays 50Rx in question.

In the example of figure 21, the receiving panel 13Rx also has an extension ey3Rx in the third direction Y comprised between 190 mm and 210 mm. Preferably, the 15 extension ey3Rx in the third direction Y is comprised between 195 mm and 205 mm. The extension ey3Rx in the third direction Y is related to the number of elementary antennas 12Tx in question.

The performance in terms of axial ratio and gain and advantages imparted by the receiving panel 13Rx are similar to the performance and advantages imparted by the 20 panel 50Rx of figure 17, as shown by studying figures 22 to 24.

In all of the embodiments, because the elementary antenna 12 has a wide band, circular polarization and good efficiency of illumination, the antenna structure 10 has a reduced bulk and a reduced weight relative to the antenna structures of the state of the art for identical radiation performance. This reduced weight makes it possible to reduce the 25 constraints in particular in the case where the entire antenna is accompanied by a mechanical positioner.

Furthermore, the production of this antenna structure 10 on a single-layer substrate makes it possible to insert easily, on the rear side at the ground plane, with the least amount of stress and impact on the radiation performance, the coupler, power 30 supply and phase shift devices to ensure monitoring and polarization choice as well as phase law and amplitude making it possible to orient the radiation pattern in the desired direction in the electronic scanning configuration.

The antenna structure 10 is also capable of emitting or receiving circularly polarized electromagnetic waves without using an additional polarizer. This better 35 compactness is accompanied by improved lightness and improved radiation performance

over a wide frequency band compatible with the targeted application. Furthermore, the antenna structure 10 is easy to produce and can be manufactured at a low cost.

Thus, the proposed antenna structure 10 is usable for telecommunications applications between two stations, in particular by satellite. It should be noted that in that case, the radiation pattern of the antenna structure 10 thus produced complies with the templates specified to be used with certain satellites.

Such an antenna structure 10 can advantageously be used in a platform, in particular aerial of the helicopter or drone type. In the context of that use, the compactness of the antenna structure 10 makes it possible to reduce the constraints on installations of equipment in the platform.

The antenna structure 10 described in reference to figure 1 is an example of an antenna structure 10 having the compactness properties previously described. Other similar antenna structures 10 can also be considered, in particular with a different number of elementary receiving 12Rx and/or emitting 12Tx antennas and a different arrangement thereof.

These different antenna structures 10 are antenna structures for telecommunications, in particular by satellite, having a reduced bulk in terms of depth and aiming capacities using an electronic scanning principle while making it possible to obtain a high-quality high-bandwidth communication, in particular in terms of gain, axial ratio and secondary lobes compatible with normative templates.

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CLAIMS

1.- An antenna structure (10) for telecommunications, in particular by satellite, comprising:

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- an emitting surface (11Tx) comprising at least one set of a plurality of elementary emitting antennas (12Tx) forming an array (50Tx), at least one elementary emitting antenna (12Tx) comprising two generally circular patches (14Tx, 16Tx) that are at least partially superimposed, said at least one elementary emitting antenna (12Tx) being dimensioned to emit at least one electromagnetic wave having a frequency comprised between 27 GHz and 31 GHz, and
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 - an receiving surface (11Rx) comprising at least one set of a plurality of elementary receiving antennas (12Rx) forming an array (50Rx), at least one elementary receiving antenna (12Rx) comprising two generally circular patches (14Rx, 16Rx) that are at least partially superimposed, said at least one elementary receiving antenna (12Rx) being dimensioned to receive at least one electromagnetic wave having a frequency comprised between 17.3 GHz and 21.2 GHz.
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20 2.- The method according to claim 1, wherein:

- each patch (14Tx, 16Tx) of said at least one elementary emitting antenna (12Tx) has a center, said elementary emitting antenna (12Tx) comprising two power supply ports (28Tx, 30Tx) able to power one of the two patches (14Tx, 16Tx), each port (28Tx, 30Tx) being in an angular sector having an angle relative to the center of the powered patch (14Tx, 16Tx) smaller than 180°, and/or
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- each patch (14Rx, 16Rx) of said at least one elementary receiving antenna (12Rx) has a center, said elementary receiving antenna (12Rx) comprising two power supply ports (28Rx, 30Rx) able to power one of the two patches (14Rx, 16Rx), each port (28Rx, 30Rx) being in an angular sector having an angle relative to the center of the powered patch (14Rx, 16Rx) smaller than 180°.
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3.- The antenna structure according to claim 1 or 2, wherein:

- the two patches (14Tx, 16Tx) of said at least one elementary emitting antenna (12Tx) are spaced apart in a first direction (Z) by a distance (ezTx) comprised between 0.5 millimeters (mm) and 2.0 mm, and/or
- the two patches (14Rx, 16Rx) of said at least one elementary receiving antenna (12Rx) are spaced apart in a first direction (Z) by a distance (ezRx) comprised between 0.5 millimeters (mm) and 2.0 mm.

4.- The antenna structure according to any one of claims 1 to 3, wherein:

- the two patches (14Tx, 16Tx) of said at least one elementary emitting antenna (12Tx) are spaced apart in a first direction (Z) by a distance (ezTx) comprised between 0.75 millimeters (mm) and 1.5 mm, and/or
- the two patches (14Rx, 16Rx) of said at least one elementary receiving antenna (12Rx) are spaced apart in a first direction (Z) by a distance (ezRx) comprised between 0.75 millimeters (mm) and 1.5 mm.

5.- The antenna structure according to any one of claims 1 to 4, wherein:

- the diameters (d1Tx, d2Tx) of the two patches (14Tx, 16Tx) of said at least one elementary emitting antenna (12Tx) are identical, and/or
- the diameters (d1Rx, d2Rx) of the two patches (14Rx, 16Rx) of said at least one elementary receiving antenna (12Rx) are identical.

6.- The antenna structure according to any one of claims 1 to 5, wherein:

- the elementary emitting antennas (12Tx) of the antenna structure (10) all comprise two generally circular patches (14Tx, 16Tx) that are at least partially superimposed, each elementary emitting antenna (12Tx) being dimensioned to emit at least one electromagnetic wave having a frequency comprised between 27 GHz and 31 GHz, and/or
- the elementary receiving antennas (12Rx) of the antenna structure (10) all comprise two generally circular patches (14Rx, 16Rx) that are at least partially superimposed, each elementary receiving antenna (12Rx) being dimensioned to receive at least one electromagnetic wave having a frequency comprised between 17,3 GHz and 21,2 GHz.

7.- The antenna structure according to claim 1 to 6, wherein the elementary emitting antennas (12Tx) and the elementary receiving antennas (12Rx) are arranged in staggered rows.

8.- The antenna structure according to any one of claims 1 to 7, wherein:

- the emitting surface (11Tx) is generally rectangular and comprises at least two sets of a plurality of elementary emitting antennas (12Tx) each forming an array (50Tx), the elementary emitting antennas (12Tx) of each set (50Tx) being along a line specific to that set, each line being parallel to the other specific lines, and/or
- the receiving surface (11Rx) is generally rectangular and comprises at least two sets of a plurality of elementary receiving antennas (12Rx) each forming an array (50Rx), the elementary receiving antennas (12Rx) of each set being along a line specific to that set, each line being parallel to the other specific lines.

9.- A platform, in particular aerial, comprising at least one antenna structure (10) according to any one of claims 1 to 8.

10.- A telecommunications method, in particular by satellite, between two stations comprising at least one of the following steps:

- a step for emitting electromagnetic waves having a frequency comprised between 27 GHz and 31 GHz via an antenna structure (10) according to any one of claims 1 to 8, and

- a step for receiving electromagnetic waves having a frequency comprised between 17,3 GHz and 21,2 GHz via an antenna structure (10) according to any one of claims 1 to 8.