ANTENNA ARRANGEMENT WITH RF COMPONENTS MOUNTED TO THE BACK SURFACE OF A REFLECTOR ELEMENT

A microwave antenna (12) for an aircraft including a reflector element (18) with a front surface (20) and a rear surface (22). A horn (28) is mounted to the front surface (20) of the reflector element (18) and an orthomode transducer (34) is mounted to the rear surface (22) of the reflector element (18). The orthomode transducer (34) is coupled to the horn (28). Solid state power amplifiers (38, 40) that amplify a microwave signal to be transmitted and low noise amplifiers (42, 44) that amplify a received microwave signal are coupled to the orthomode transducer (34). The solid state amplifiers (38, 40) and the low noise amplifiers (42, 44) are also located on the rear surface (22) of the reflector element (18).
ANTENNA ARRANGEMENT WITH RF COMPONENTS MOUNTED TO THE BACK SURFACE OF A REFLECTOR ELEMENT

FIELD OF THE INVENTION

[0001] The present invention relates to a microwave reflector antenna and, more specifically, to a microwave reflector antenna for attachment to an aircraft.

BACKGROUND OF THE INVENTION

[0002] Microwave reflector antennas can be used in airborne applications. For example, microwave reflector antennas can be used on an aircraft to allow the aircraft to communicate with other parties. When the microwave reflector antenna is used on an aircraft, the microwave reflector antenna may be positioned on the crown of the exterior of the aircraft. The positioning of the microwave reflector antenna on the exterior of the aircraft increases the drag of the aircraft as it travels through the atmosphere and exposes the microwave reflector antenna to the harsh environments that the aircraft is exposed to. Therefore, the microwave reflector antennas are typically covered by a radome which completely covers the microwave reflector antenna and reduces the drag caused by positioning the microwave reflector antenna on the exterior of the aircraft.

[0003] Because the cost of the radome is proportional to the size of the radome, any reduction in the height of the radome will result in a cost savings. Additionally, decreasing the size of the radome will also decrease the drag caused by the radome on the aircraft. Therefore, it is desirable to reduce the height of the microwave reflector antenna so that the height of the radome can also be reduced.

[0004] Additionally, RF components such as orthomode transducers (OMT's), solid state power amplifiers (SSPA's), and low noise amplifiers (LNA's) are often used in reflector antennas. These components typically are remotely located from the antenna. However, if the RF components are remotely located from the antenna, the waveguide which interconnects the
antenna to the RF components will introduce higher RF losses. RF losses occur because the RF components are typically located by a distance of many feet away from the antenna and the interconnecting waveguide is too long. Waveguides are also difficult to fabricate, costly, heavy, and difficult to install into aircraft.

[0005] Furthermore, the use of a waveguide to connect the antenna to the remotely located RF components requires a waveguide azimuth rotary joint. A rotary joint is used to interconnect the movable antenna to the stationary aircraft fuselage. A waveguide rotary joint is considerably larger and more costly than a coaxial rotary joint. As a result, antennas that use a waveguide rotary joint are larger and increase drag.

[0006] Therefore, a microwave reflector antenna that utilizes RF components mounted directly onto the antenna is needed so the antenna has a minimum height, minimum RF losses, and so the antenna may utilize a coaxial rotary joint. Also, if the antenna has a minimum height, the radome necessary to cover the antenna will also be of a minimum size which will reduce the cost to build and operate a microwave antenna, reduce aerodynamic drag, and reduce the swept volume of the microwave antenna.

SUMMARY OF THE INVENTION

[0007] The present invention provides a microwave antenna for an aircraft including a reflector element with a front surface and a rear surface. A horn is mounted to the front surface of the reflector element and an orthomode transducer is mounted to the rear surface of the reflector element. The orthomode transducer is coupled to the horn. Solid state power amplifiers that amplify a microwave signal to be transmitted and low noise amplifiers that amplify a received microwave signal are coupled to the orthomode transducer. The solid state amplifiers and the low noise amplifiers are also located on the rear surface of the reflector element.

[0008] The inherent advantage of this design is that it permits the use of smaller RF components such as the LNA's and the SSPA's. These lower
wattage units have less concentrated heat to dissipate, can be readily mounted directly onto the antenna and result in the lowest possible RF losses.

[0009] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0011] Figure 1 is a top view of a microwave antenna array of the present invention;

[0012] Figure 2a is a side view of a microwave antenna of the present invention;

[0013] Figure 2b is a rear view of a microwave antenna of the present invention;

[0014] Figure 3 is a schematic view of RF components mounted to the microwave antenna; and

[0015] Figure 4 is a block diagram of RF components connected to a coaxial adapter.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] The following description of the preferred embodiments is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0017] Referring to Figure 1, a linear array 10 of microwave antennas 12 is shown. Although an array 10 of four microwave antennas 12 is shown, any number of microwave antennas 12 may be used and is not out of the scope of the present invention.
[0018] The array 10 is capable of rotating about two different axes. A first axis of rotation is an azimuth axis. Rotation of the array 10 about the azimuth axis allows the array 10 to rotate 360° so that the array 10 can point in any direction along the horizon. A second axis of rotation is the elevation axis. Rotation of the array 10 about the elevation axis allows the elevation of the array 10 to be adjusted so that the array 10 can be oriented between the horizon and the sky.

[0019] In order to rotate the array 10 about the azimuth axis, the array 10 is connected to an azimuth stepper motor 14. In order to rotate the array 10 about the elevation axis, the array is also connected to an elevation stepper motor 16. It should be noted that any azimuth stepper motor 14 or any elevation stepper motor 16 may be used that is known in the art.

[0020] Figures 2a and 2b show a preferred embodiment of a microwave antenna 12 that is used in the array 10.

[0021] As can be seen in Figure 2a, the microwave antenna 12 includes a reflector element 18 that has reflective surface 20 and a back surfaces 22. A portion 24 of the front surface 20 is concave and reflects microwave energy that strikes the concave portion 24 of the front surface 20. Preferably, the back surface 22 of the reflector element 18 is convex, however, the back surface 22 does not need to be convex to be within the scope of the invention. A preferably plastic support tube 26 extends radially outward from the front surface 20 of the reflector element 18. A wide band horn 28, shown in phantom, is also positioned on the front surface 20 of the reflector element 18 proximate a rear portion 30 of the support tube 26. More particularly, the horn 28 is located within the rear portion 30 of the support tube 26. A sub-reflector 32, shown in phantom, is positioned in front of the horn 28 proximate a front portion 33 of the support tube 26. More particularly, the sub-reflector 32 is located within the front portion 33 of the support tube 26. The horn 28 emits microwave energy which is directed at the sub-reflector 32. The sub-reflector 32 reflects the microwave energy towards the concave portion 24 of the front surface 20 of the reflector element 18. The
concave portion 24 of the front surface 20 of the reflector element 18 then reflects the microwave energy in a desired direction.

[0022] The horn 28 receives microwave energy that is directed by the sub-reflector 32. The concave portion 24 of the front surface 20 of the reflector element 18 reflects the microwave energy toward the sub-reflector 32. The sub-reflector 32 then reflects the microwave energy toward the horn 28.

[0023] The reflector element 18 is preferably a Cassegrain reflector, but may be any reflector element 18 that is known in the art that can perform a transmit function (TX) and receive function (RX).

[0024] The horn 28 is preferably a corrugated horn, but may be any horn 28 that is known in the art.

[0025] An orthomode transducer (OMT) 34 extends from a back surface 22 of the reflector element 18 and is directly coupled to the horn 28. OMT 34 is a device that serves to combine or separate orthogonally polarized signals. The orthogonally polarized signals may have a vertical polarization or a horizontal polarization.

[0026] As can also be seen in Figure 2b, RF components 36 such as solid state power amplifiers (SSPA’s) 38, 40 and low noise amplifiers (LNA’s) 42, 44 are located on the back surface 22 of the reflector element 18 and are adjacenty mounted to the OMT 34. The configuration of the RF components 36 is merely exemplary and should not be limited to that illustrated.

[0027] The SSPA’s 38, 40 serve to amplify the transmission signal. A vertical polarization SSPA 38 is mounted orthogonally relative to the OMT 34 and amplifies a vertical polarization of the signal to be transmitted. A horizontal polarization SSPA 40 is mounted orthogonally relative to the OMT 34 and amplifies a horizontal polarization of the signal to be transmitted.

[0028] The LNA’s 42, 44 serve to amplify the signal that is received. A vertical polarization LNA 42 is mounted orthogonally relative to the OMT 34 and amplifies a vertical polarization of the signal that is received. A horizontal polarization LNA 44 is mounted orthogonally relative to the OMT 34 and amplifies a horizontal polarization of the signal that is received.
[0029] In other words, the vertical polarization SSPA 38 and the vertical polarization LNA 42 radially extend from the OMT 34, opposite one another. The horizontal polarization SSPA 40 and the horizontal polarization LNA 44 also radially extend from the OMT 34, opposite one another. The vertical polarization SSPA 38 is orthogonally adjacent to both the horizontal polarization SSPA 40 and the horizontal polarization LNA 44. The vertical polarization LNA 42 is also orthogonally adjacent to both the horizontal polarization SSPA 40 and the horizontal polarization LNA 44.

[0030] Now referring to Figure 3, the OMT 34 is connected to short sections of ½ height waveguide 46, 48, 50, and 52 via circulators 54, 56. The first circulator 54 is used for TX (transmission function) and the second circulator 56 is used for RX (receive function). The first circulator 54 (for TX) is connected to a TX-H waveguide 46 and to a TX-V waveguide 48. The TX-H waveguide 46 carries the horizontal polarization state of the signal to be transmitted. The TX-V waveguide 48 carries the vertical polarization state of the signal to be transmitted. The TX-H waveguide 46 is further connected to the horizontal polarization SSPA 40. The TX-V waveguide 48 is further connected to the vertical polarization SSPA 38.

[0031] The second circulator 56 (for RX), shown in phantom, is connected to a RX-H waveguide 50 and to a RX-V waveguide 52. The RX-H waveguide 50 carries the horizontal polarization state of the received signal. The RX-V waveguide 52 carries the vertical polarization state of the received signal. The RX-H waveguide 50 is further connected to the horizontal polarization LNA 44. The RX-V 52 waveguide is further connected to the vertical polarization LNA 42.

[0032] Referring to Figure 4, the SSPA’s 38, 40 are connected to ½ height waveguides 58, 60 that run to a single channel elevation waveguide rotary joint 62. The LNA’s 42, 44 are also connected to ½ height waveguides 64, 66 that run to another single channel waveguide rotary joint 68. The RX signals and TX signals pass then pass through diplexers 70, 72 and through a waveguide 74 to a coaxial adapter 76. This design permits both signals (TX
and RX) to pass through a coaxial rotary joint (not shown) and then on to the
RF processing system that is located within the fuselage of the aircraft.

[0033] The SSPA's 38,40 and LNA's 42,44 used in the present
invention are preferably 5 watt amplifiers. These lower wattage components
have less concentrated heat to dissipate and can be readily mounted directly
onto the back surface 22 of the reflector element 18 as a result of their small
size. By mounting the RF components 36 directly onto the back surface 22 of
the reflector element 18, RF losses are kept to a minimum as a result of the
signal being immediately amplified by the SSPA's 38, 40 and the LNA's 42,44.

By amplifying the signal immediately (rather than after passing through
waveguides), a much stronger signal travels through waveguides 58, 60, 64,
and 66 to the single channel elevation rotary joints 62, 68.

[0034] Furthermore, mounting the RF components 36 to the back
surface 22 of the reflector element 18 enables using a coaxial rotary joint as
opposed to an waveguide azimuth rotary joint which reduces antenna height
and swept volume. The minimization of the microwave antenna 12 also
lowers the size of the radome and aerodynamic drag, which in turn lowers the
cost to build and operate the microwave antenna 12.

[0035] The description of the invention is merely exemplary in nature
and, thus, variations that do not depart from the gist of the invention are
intended to be within the scope of the invention. Such variations are not to be
regarded as a departure from the spirit and scope of the invention.
CLAIMS

What is claimed is:

1. A microwave antenna for an aircraft comprising:
   a reflector element with a reflective surface and a back surface; and
   a plurality of RF components,
   wherein the RF components are mounted to the back surface of the
   reflector element.

2. The microwave antenna according to claim 1, wherein the RF
   components include an orthomode transducer, at least one solid state
   power amplifier, and at least one low noise amplifier.

3. The microwave antenna according to claim 1, wherein the solid
   state power amplifiers and low noise amplifiers further comprise 5 watt
   amplifiers.

4. The microwave antenna according to claim 1, further comprising:
   at least one first waveguide connected between the orthomode
   transducer and the solid state power amplifiers; and
   at least one second waveguide connected between the
   orthomode transducer and the low noise amplifiers.

5. The microwave antenna according to claim 4, wherein the first and
   second waveguide further comprise ½ height waveguides.

6. A microwave antenna for an aircraft comprising:
   a reflector element with a reflective surface and a back surface;
   a horn mounted to the front surface of the reflector element;
   an orthomode transducer mounted to the back surface of the
   reflector element, the orthomode transducer coupled to the horn;
a first solid state power amplifier located on the back surface of the reflector element and coupled to the orthomode transducer;
a second solid state power amplifier located on the back surface of the reflector element and coupled to the orthomode transducer;
a first low noise amplifier located on the back surface of the reflector element and coupled to the orthomode transducer; and
a second low noise amplifier located on the back surface of the reflector element and coupled to the orthomode transducer.

7. The microwave antenna according to claim 6, wherein the first and second solid state power amplifiers and first and second low noise amplifiers further comprises 5 watt amplifiers.

8. The microwave antenna according to claim 6, further comprising:
a first set of two waveguides connected between the orthomode transducer to the solid state amplifiers; and
a second set of two waveguides connected between the orthomode transducer to the low noise amplifiers.

9. The microwave antenna according to claim 8, wherein the first and second set of waveguides further comprise ½ height waveguides.

10. An array of microwave antennas for an aircraft, each antenna in the array comprising:
a reflector element with a reflective surface and a back surface;
a support tube with a rear portion and a front portion, the support tube extending from the reflective surface of the reflector element;
a horn located proximate the rear portion of the support tube and on the front surface of the reflector element;
an orthomode transducer located on the back surface of the reflector element, the orthomode transducer coupled to the horn;
a vertical polarization solid state power amplifier coupled to the orthomode transducer by a first vertical polarization waveguide;

a horizontal polarization solid state power amplifier coupled to the orthomode transducer by a first horizontal polarization waveguide;

a vertical polarization low noise amplifier coupled to the orthomode transducer by a second vertical polarization waveguide; and

a horizontal polarization low noise amplifier coupled to the orthomode transducer by second horizontal polarization waveguide.

11. The array according to claim 10, wherein the solid state power amplifiers and the low noise amplifiers further comprise 5 watt amplifiers.

12. The array according to claim 10, wherein the waveguides further comprise ¼ height waveguides.

13. The array according to claim 10, wherein a sub-reflector is located proximate a front portion of the support tube.

14. The array according to claim 10, wherein the horn further comprises a corrugated horn.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7  H01Q1/28  H01Q15/14  H01Q19/19  H01P1/161

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)

IPC 7  H01Q  H01P  H04B

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)

INSPEC, EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of box C.

X Patent family members are listed in annex.

* Special categories of cited documents:
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Date of the actual completion of the international search

6 March 2003

Date of mailing of the International Search Report

27.03.2003

Name and mailing address of the ISA

European Patent Office, P.B. 6818 Patentlaan 2 NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 851 epc nl, Fax. (+31-70) 340-3216

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