(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 137 102 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.09.2001 Bulletin 2001/39

(51) Int Cl.[7]: **H01Q 15/00**, H01Q 19/195

(21) Application number: **01106761.8**

(22) Date of filing: **17.03.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **20.03.2000 US 528605**

(71) Applicant: **THE BOEING COMPANY**
Seattle, Washington 98124-2207 (US)

(72) Inventors:
- **Ramanujam, Parthasarathy**
Redondo Beach, California 90278 (US)
- **Goyette, Guy**
Marina Del Rey, California 90292 (US)
- **Moncada, John J,**
Gardena, California 90247 (US)

(74) Representative: **Steil, Christian, Dipl.-Ing. et al**
Witte, Weller & Partner,
Postfach 10 54 62
70047 Stuttgart (DE)

(54) **Frequency variable aperture reflector**

(57) A frequency variable aperture reflector (18) for working in a first and second frequency band, wherein the first frequency band is higher than the second frequency, includes a radiating element having an active surface (20) and a frequency selective surface (22). The active surface (20) is a contiguous surface capable of reflecting both the first and second frequency bands. The frequency selective surface (22) surrounds the active surface (20) and only reflects the second frequency band (Fig. 2).

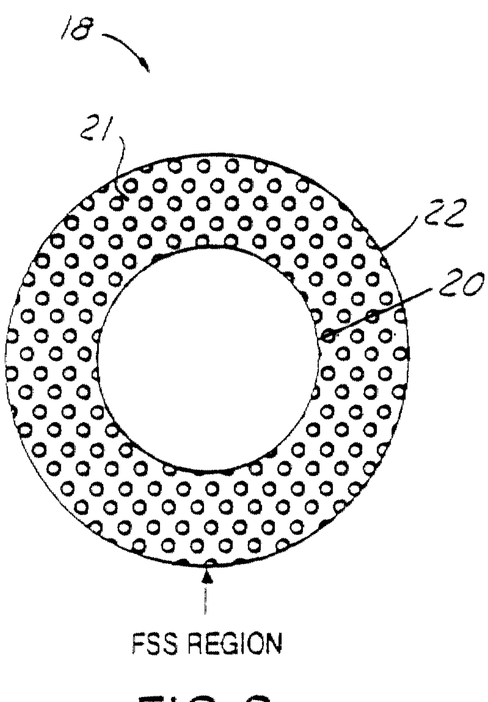

FIG. 2

EP 1 137 102 A2

Description

TECHNICAL FIELD

[0001] The present invention relates generally to antennas, and more particularly, to a frequency variable aperture reflector.

BACKGROUND ART

[0002] It is well accepted that the gain of a radiating reflector antenna increases with the increase of the operational signal frequency. Likewise, the antenna aperture angle of a radiating reflector antenna decreases with the increase of the operational signal frequency. In the case of a parabolic reflector illuminated at its center, for example, gain is a function of the square of the operation frequency.

[0003] It follows from this increase in gain and this decrease in the aperture angle that an antenna that was designed for one or more given frequency bands can no longer be used beyond a certain value. Firstly because its radiated power is too great in relation to what is accepted under the FCC standards. Secondly because its aperture angle is so fine that the least vibration or the least torsion of the antenna support would result in misalignment of the antenna.

[0004] Accordingly, this variation in gain as a function of frequency limits the number of frequency bands in which a given antenna may be used and results in separate antenna being used when the operation frequency bands lead to deviations in gain that are not acceptable. This solution, which consists of using multiple antennas, is not desirable for satellite applications due to weight restrictions and reliability requirements. Thus there exists a need to design a single reflector antenna capable of being used efficiently for multiple frequencies over a wide range.

SUMMARY OF THE INVENTION

[0005] It is, therefore, an object of the invention to provide an improved and reliable frequency variable aperture reflector. Another object of the invention is to provide a single reflector antenna capable of being used efficiently for multiple frequency bands over a wide frequency range.

[0006] In one aspect of the invention, a frequency variable aperture reflector for working in a first and second frequency band, where the first frequency band is higher then the second frequency, includes a radiating element having an active surface and a frequency selective surface. The active surface is a contiguous surface capable of reflecting both the first and second frequency bands. The frequency selective surface surrounds the active surface and only reflects the second frequency band.

[0007] The present invention thus achieves an improved frequency variable aperture reflector. The present invention is advantageous in that it improves antenna performance while eliminating the need for multiple antennas. This invention is ideal for radiometer applications where constant beamwidths are required over multiple frequency bands.

[0008] Additional advantages and features of the present invention will become apparent from the description that follows, and may be realized by means of the instrumentalities and combinations particularly pointed out in the appended claims, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] In order that the invention may be well understood, there will now be described some embodiments thereof, given by way of example, reference being made to the accompanying drawings, in which:

FIGURE 1 is a perspective view of a satellite antenna system according to one embodiment of the present invention;

FIGURE 2 is a plan view of a frequency variable aperture reflector according to one embodiment of the present invention;

FIGURE 3 is a cross section of a frequency variable aperture reflector according to one embodiment of the present invention; and

FIGURE 4 is a plan view of the geometry of the frequency selective surface according to one embodiment of the present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

[0010] Referring to FIGURE 1, a perspective view of a satellite antenna system 10 according to one embodiment of the present invention is illustrated. Satellite antenna system 10 is comprised of one or more satellites 12 in communication with a ground station 14 located on the Earth 16. Each satellite 12 contains one or more frequency variable aperture reflectors 18.

[0011] Reflector 18 can be used in both a transmit and receive mode of operation, each mode having a different frequency. A diplexer connected behind the common transmit/receive feed(s) allows satellite 12 to separate the transmit signal from the receive signal. Because the beam size is a function of signal wavelength and the transmit signal and receive signal operate at different frequencies, the transmit and receive beams will be of different size unless a frequency selective surface on the antenna is used. By using a frequency selective surface, it is possible to produce equal size beams at the transmit and receive frequencies. The frequency selective surface portion of reflector 18 is designed to be reflective at the lowest frequency and transparent at the highest frequency. If D_1 is the total linear diameter of the reflector at the lowest frequency and D_2 is the diameter of the reflector required to produce the same beam size at the highest frequency then:

$$D_1 = D_2 + 2h$$

Where h is the width of the frequency selective surface located on the outside portion of the reflector.

[0012] Referring to FIGURE 2, a plan view of a frequency variable aperture reflector 18 according to one embodiment of the present invention is illustrated. Reflector 18 is a satellite dish antenna used to transmit and receive signals in a first frequency band and a second frequency band from satellite 12 to ground station 14. The first frequency band is higher then the second frequency band.

[0013] Reflector 18 includes an active surface 20 and a frequency selective surface 22. Active surface 20 has a substantially contiguous surface capable of reflecting both the first and second frequency bands. Frequency selective surface 22 is adjacent to and surrounds active surface 20 and has a non-contiguous surface designed to reflect the second frequency band with little or no attenuation, while being transmissive to the first frequency band. While the preferred embodiment uses only one frequency reflective surface, one skilled in the art would also recognize that a second frequency selective surface adjacent to and surrounding the frequency selective surface could be used. The second frequency selective surface would be reflective to a third frequency band, while being transmissive to the first and second frequency band. Additional frequency selective surfaces could be added, as additional frequency bands are required.

[0014] Referring to FIGURE 3, a cross section of a frequency variable aperture reflector 18 according to one embodiment of the present invention is illustrated. In the present example, a single parabolic reflector 18 is used. One skilled in the art, however, would recognize that a shaped reflector, which is designed to produce shaped beams could be also be used. One skilled in the art would also recognize that the current teachings could be extended to dual or multi-reflector systems.

[0015] With reference to a Ka band antenna, FIGURE 3 shows the geometry of a single offset reflector 18 with a diameter of fifty inches feed by a corrugated horn operating at twenty and thirty giga-hertz where active surface 20 is disposed on a dielectric substrate. Without frequency selective surface 22, the beam width of this antenna is about one degree at twenty giga-hertz and 0.65 degrees at thirty giga-hertz, which is undesirable.

[0016] While the present invention is illustrated with a doubly curved reflector, one skilled in the art would recognize that this concept is also applicable to singly curved reflectors, such as parabolic cylinders fed by an array. The frequency selective surface (FSS) for a singly curved reflector is much easier to design than for a doubly curved reflector. The singly curved FSS needs to be designed for a constant =0 and ± , whereas the doubly curved FSS needs to be designed for both ± and ±.

[0017] Referring to FIGURE 4, a plan view of the geometry 24 of the frequency selective surface according to one embodiment of the present invention is illustrated. Geometry 24 is made up of a plurality of conducting rings 26 on a dielectric substrate. The outer eight inches of reflector 18 uses the frequency selective surface 22. This surface almost completely reflects any incident field at 20 giga-hertz and transmits almost completely at thirty giga-hertz. Though a simple ring 26 design is shown, many other implementations of frequency selective surface 22 are possible. For example, other frequency selective surfaces include, a plurality of periodic conduction lines radiating away from active surface 20, a plurality of periodic concentric circle arrays encircling the active surface 20, or a plurality of periodic circular holes or slots.

[0018] From the foregoing, it can be seen that there has been brought to the art a new and improved frequency variable aperture reflector. It is to be understood that the preceding description of the preferred embodiment is merely illustrative of some of the many specific embodiments that represent applications of the principles of the present invention. Clearly, numerous and other arrangements would be evident to those skilled in the art without departing from the scope of the invention as defined by the following claims:

Claims

1. A frequency variable aperture reflector (18) for working in a first frequency band and a second frequency band, wherein said first frequency band is a higher frequency than said second frequency band, said reflector (18) being **characterized by**:

   an active surface (20) comprising a substantially contiguous surface reflective for said first frequency band and said second frequency band with approximately zero attenuation; and
   a frequency selective surface (22) adjacent to and surrounding said active surface (20) and comprising a non-contiguous surface reflective for said second frequency band with approximately zero attenuation, said frequency selective surface (22) being not reflective for said first frequency band.

2. The reflector of claim 1, **characterized in that** said frequency selective surface (22) comprises a plurality of periodic conduction rings (26) arrayed on a dielectric substrate.

3. The reflector of claim 1, **characterized in that** said frequency selective surface comprises a plurality of periodic conduction lines arrayed on a dielectric substrate and radiating away from said active surface (20).

4. The reflector of claim 1, **characterized in that** said frequency selective surface comprises a plurality of periodic conduction circles arrayed on a dielectric substrate and encircling and radiating away from said active surface (20).

5. The reflector of any of claims 1 - 4, **characterized in that** said frequency selective surface (22) and said active surface (20) are contiguous, said frequency selective surface (22) having a plurality of periodic openings formed therein.

6. The reflector of claim 5, **characterized in that** said openings are circular.

7. The reflector of claim 5, **characterized in that** said openings are slots.

8. The reflector of any of claims 1 - 7, **characterized in that** said reflector is adapted for working in a third frequency band, wherein said third frequency band is a lower frequency then said second frequency band, said reflector further comprising a second frequency selective surface adjacent to and surrounding said frequency selective surface and comprising a non-contiguous surface reflective for said third frequency band with approximately zero attenuation, said second frequency selective surface being not reflective for said first frequency band and said second frequency band.

9. The reflector of any of claims 1 - 8, **characterized in that** said reflector (18) is a shaped reflector.

10. A satellite antenna system (10), comprising:

a ground station (14);
a satellite (12) in orbit and in communication with said ground station (14), said satellite being **characterized by** a frequency variable aperture reflector (18) according to any of claims 1 - 9.

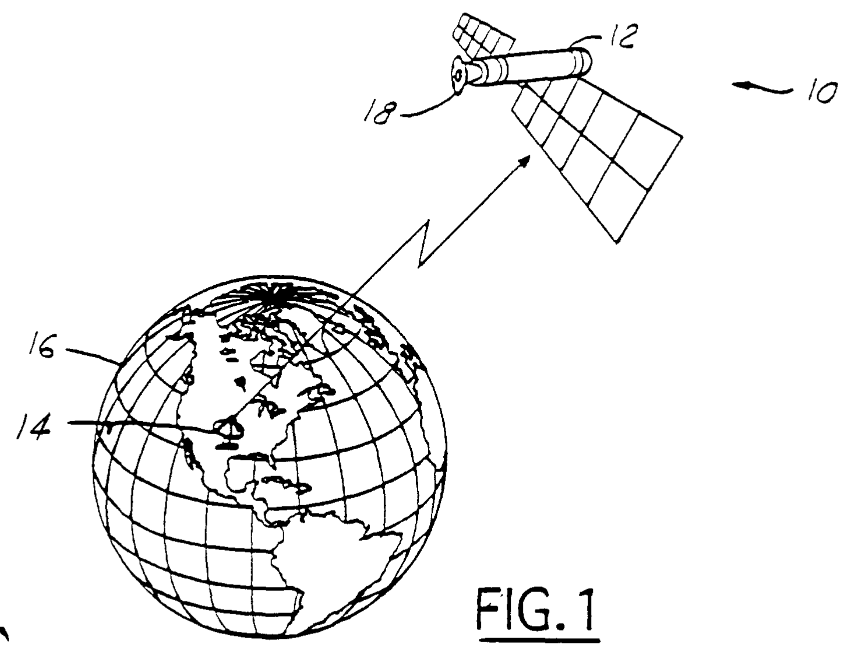

FIG. 1

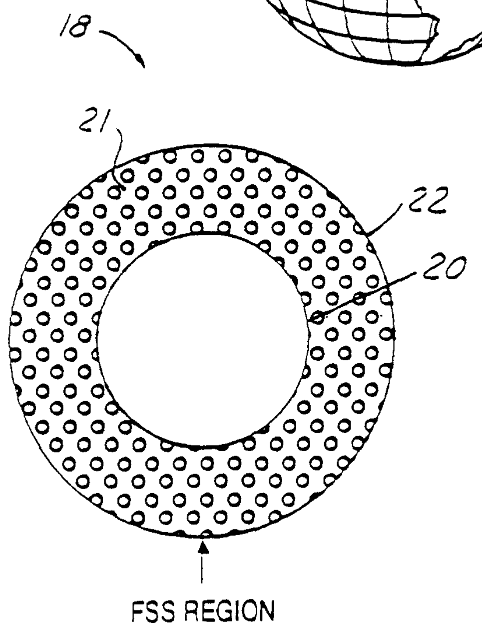

FIG. 2

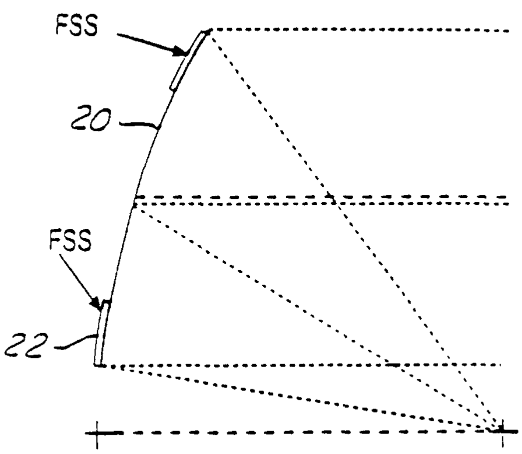

FIG. 3

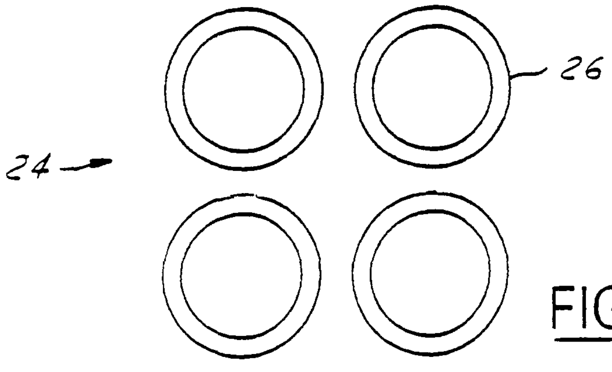

FIG. 4