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United States Patent
Hardman , et al.**10,601,122**
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S-band antenna

Abstract

An antenna includes a body support structure, an extruding mechanism to exert an extrusion force, an extrusion plate to inhibit motion of an extension plate, an extrusion support structure, a nadir panel including one or more communication patches; one or more petals including one or more additional communication patches, one or more extension arms, and an extension mechanism exert an extension force upon the extension plate. The relative position and orientation of the components are altered by the operation of the extension mechanism and the extension mechanism from a stowed state to an extruded state to an extended state. A control system may be included to initiate and control the state of the antenna as well as operate the communications of the antenna once deployed.

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Claims

What is claimed is:

1. An antenna comprising: a body support structure: coupled to an extruding mechanism; and having an inner diameter of the body support structure slidably engaged to an outer diameter of an extrusion plate; the extruding mechanism: coupled to the body support structure; engaged with the extrusion plate; and coupled to exert an extrusion force on the extrusion plate; the extrusion plate: having the outer diameter of the extrusion plate slidably engaged with the inner diameter of the body support structure; engaged with and able to receive the extrusion force from the extruding mechanism; coupled to an extrusion support structure; and having a receiving surface to inhibit movement of an extension plate; the extrusion support structure: coupled to the extrusion plate; having an outer diameter of the extrusion support structure slidably engaged to an inner diameter of the extension plate; and coupled to a nadir panel; the nadir panel: comprising one or more communication patches; coupled to the extrusion support structure; rotatably coupled to one or more petals; and able to receive an extension force from an extension mechanism; the one or more petals: comprising one or more additional communication patches; each rotatably coupled to the nadir panel; and each rotatably coupled to one of one or more extension arms; the one or more extension arms: each rotatably coupled to one or more of the one or more petals; and each rotatably coupled to the extension plate; the extension plate: having the inner diameter of the extension plate slidably engaged to the outer diameter of the extrusion support structure; rotatably coupled to the one or more extension arms; and coupled to receive the extension force from the extension mechanism; and the extension mechanism to contact and exert the extension force upon the nadir panel and the extension plate; and wherein the extrusion plate, the extrusion support structure, the nadir panel, the one or more petals, the one or more extension arms, the extension plate, and the extension mechanism the extrusion force are stored within the body support structure in a stowed state and the extrusion force moves at least the nadir panel, the one or more petals, the one or more extension arms, the extension plate, and the extension mechanism outside the body support structure to an extruded state; and wherein the extension plate is moved by the extension force to contact a receiving surface of the extrusion plate, the extension plate and the one or more extension arms rotating the one or more petals to an extended state, the one or more petals oriented at an angle relative to the nadir panel based on a distance of the extension plate from the nadir panel in the extended state, a length of the one or more extension arms, and a length of the one or more petals.

2. The antenna of claim 1, wherein the extruding mechanism comprises: a rod coupled to the body support structure and slidably engaged with the extrusion plate; a spring between the body support structure and the extrusion plate; and a latch to: maintain the spring coiled in the stowed state; and operable to release the spring in the extruded state and the extended state.

3. The antenna of claim 1, wherein: the extruding mechanism comprises: a threaded rod coupled to the body support structure and engaged with the extrusion plate; and a motor operable to turn the threaded rod to transition from the stowed state to the extruded state; and the extrusion plate comprising opposing threads to the threaded rod.

4. The antenna of claim 1, wherein the one or more communication patches of the nadir panel are C-band patches.

of the satellite 200. The body 202 of the satellite 200 may be hollow to store the antenna 302 and the antenna extension assembly 502. The antenna 302 does not extend past the body 202 of the satellite 200. This enables the satellite 200 to minimize the volume when stored on a carrier craft. The satellite 200 may further have panels on the body 202 that may be deployed and folded to minimize the volume on a carrier craft. The antenna 302 may be deployed before, along with, or after the panels. For example, a control system may detect that the panels have been deployed and, in response, initiate the deployment of the antenna 302.

After the deployment of the antenna 302 is initiated, the antenna 302 transitions (FIG. 3) to the extruded state (FIG. 4). The antenna 302 is moved relative to the body 202 of the satellite 200. The transition to the extruded state may be performed through the operation of a motor-driven device or a stored-energy device, such as a spring. The motor-driven method may enable the speed of deployment to be controllable. For example, a motor turning a threaded rod or screw to drive the antenna 302 out of the body 202 of the satellite 200 may control the rate of the rotation of the threaded rod or screw. Further, a control system may determine when the extruded state has been reached by the number of turns of the screw or rod mechanism. The system may then perform the transition to the extended state. For a stored potential method, a latch, or other mechanism, may hold the antenna 302 in place, and release the antenna 302 by the action of the control system.

Once the satellite 200 is in the extruded state (FIG. 4), the satellite 200 may transition (FIG. 5) to the extended state (FIG. 6). A further motor or potential energy system may be utilized. The extension system moves the antenna extension assembly 502 back toward the body 202 of the satellite 200. The antenna extension assembly 502 then operates to extend the petals of the antenna 302 when the antenna extension assembly 502 is moved toward the body 202 of the satellite 200. In one embodiment, a spring is coiled and exerting a spring force upon the antenna extension assembly 502, being held in place by a latch. Once the extruded state is reached, the latch is operated, thereby releasing the spring. The spring drives the antenna extension assembly 502 toward the body 202 of the satellite 200. The antenna extension assembly 502 then extends the petals of the antenna 302. The antenna extension assembly 502 may further come to rest against additional structure of the satellite 200.

In some embodiments, the satellite 200 does not reach a full extruded state prior to the transition to the extended state being initiated. The control system may at a point of partial extrusion, initiate the extension of the antenna 302 by the antenna extension assembly 502. In another embodiment, as the antenna 302 reaches a partially extruded state, a mechanical device, such as a latch may be operated by the movement of the antenna 302 in the extrusion transition to initiate the extension transition.

Referring to FIG. 7, an antenna 700 comprises a support structure 702, a petal 704-petal 718, S-band patches 720, a nadir panel 722, C-band patches 724, an extension plate 726, and an extension arm 728.

The support structure 702 is coupled to the body of the satellite. The support structure 702 may be attached with fasteners, welds, etc., may be press fit into the body of the satellite, or may have components that fit into grooves of the body of the satellite. The support structure 702 may be further coupled to other components of the antenna 700 to ensure the satellite remains integrated.

The petal 704-petal 718 are coupled to the nadir panel 722 and each to one extension arm 728. The petal 704-petal 718 may be rotatably coupled to each of the nadir panel 722 and the extension arm 728. As the extension plate 726 is moved toward the support structure 702 during the extension phase, force is exerted on each petal via the extension arm 728. The force is then applied to each rotatable joint causing each of the petals to align at a specified angle to the nadir panel 722 once the extension plate 726 has come to rest, e.g. between 5 and 45 degrees. The angle at which each of the petals is maintained contributes to the communication profile of the beams sent and received. As depicted in FIG. 7, the antenna 700 comprises eight (8) petals. In other embodiments, a different number of petals is utilized, such as six (6) petals. In many embodiments, the number of petals is an even number as the petals are grouped as send and receive pairs of petals. A send petal may have neighboring petals that are receive petals (and vice versa) to help ensure that a send petal and a receive petal is oriented toward a ground station. As the number of petals decreases, the antenna 700 is less likely to have an orientation to communicate with a ground station. Increasing the number of petals may increase the size of the antenna 700 (to maintain the same petal size) or decrease the size of each petal. Decreasing the size of each petal may then result in a reduced size of the S-band patches 720, which alters the beam profile for communication. The petal 704-petal 718 each are coupled to one or

embodiments, the patches are oriented such that the normal direction to the patch while the satellite orbits the Earth corresponds to a point on the Earth to enable peak gain.

The transmission lines 920 electrically couple the patches to the control system of the satellite. The transmission lines 920 may be a parallel feed, or another feed system, such as the corporate feed depicted. The transmission lines 920 may be constructed as to ensure the length of the feed from each patch is of the same length. While each patch may operate at a specific resistance (e.g., 50 ohms), combining the feeds from each patch may reduce such resistance (e.g., for eight patches in parallel, 6.25 ohms). The transmission lines 920 thus may utilize the impedance transformer 922-impedance transformer 932 after each joint to increase the resistance of the signal from the junction.

Terms herein should be accorded their ordinary meaning in the arts unless otherwise indicated expressly or by context:

"Angle" herein refers to the supplementary angle to the angle of the rotational joint between the nadir panel and a petal.

"C-band patches" herein refers to material to communicate in the C-Band, the microwave range of frequencies ranging from 4.0 to 8.0 gigahertz (GHz).

"Communication signal" herein refers to information transmitted by electromagnetism.

"Dielectric constant" herein refers to a quantity measuring the ability of a substance to store electrical energy in an electric field.

"Dielectric material" herein refers to a medium or substance that transmits electric force without conduction, such that it acts as an insulator.

"Extension force" herein refers to a mechanical force applied to the antenna to cause the petals to rotate to the designated angle with the nadir plate.

"Extrusion force" herein refers to a force exerted on the antenna to translate multiple components of the antenna from within the body support structure to outside the body support structure.

"Ground terminal" herein refers to a terrestrial radio station designed for extraplanetary telecommunication with the antenna.

"Horizon angle" herein refers to an angle measure from the horizon of the surface of an object from which the ground terminal transmits.

"Impedance transformer" herein refers to an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction to match the impedances of the circuits.

"Motor" herein refers to a machine, which may be powered by electricity or internal combustion, that supplies motive power for a vehicle or for some other device with moving parts.

"One or more communication patches" herein refers to material utilized to send and receive signals utilizing the electromagnetic frequency spectrum.

"Receive petal" herein refers to a petal of a communication array with communication patches configured to receive communication signals.

"S-band patches" herein refers to material to communicate in the S-Band, utilizing the microwave band of the electromagnetic spectrum covering frequencies from 2 to 4 gigahertz (GHz).

"Send petal" herein refers to a petal of a communication array with communication patches configured to send communication signals.

"Transmission lines" herein refers to electrically conductive material utilize to electrically couple communication patches.

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