

AN ANTENNA DEVICE**FIELD OF INVENTION**

5 The present invention relates to an antenna arrangement and more particularly to an antenna arrangement that includes an antenna reflector, an antenna holding unit, a transceiver element, a sensor unit and a signal detecting unit for processing signals arriving from a target and for generating on
10 the basis of these signals control signals for guiding the antenna reflector into alignment with the target.

The antenna arrangement may be stationary or mounted on a moveable support surface, in other words intended for
15 stationary equipment, land mobile equipment or marine equipment. The signal detecting unit includes a signal converter and a computing unit in series.

BACKGROUND OF THE INVENTION

20 It is known to use in antenna arrangements of this kind separate pointing and tracking systems whose purpose is to optimise the bearing between, e.g., land-based antenna arrangements and satellites so as to obtain correct alignment
25 therebetween. The investment costs in achieving optimal dynamic pointing accuracy with the antenna arrangement in such systems is very high. This antenna pointing accuracy can be influenced by externally acting forces, such as movement of the antenna supporting surface, the wind, and wave motion,
30 for example.

Because the matter concerns an antenna arrangement and a target that move relative to one another, high demands are placed on the pointing system. These high demands, in turn,
35 limit the choice of equipment for detecting signals arriving from the target to solely extremely expensive equipment.

In view of the requirement of high dynamic pointing accuracy, mono-pulse technology is used. However, this technology normally requires high investment in signal detection equipment such as broadband spectrum analysers and the like
5 in achieving the effect desired.

Several known systems lack the possibility of correcting for the drift and instability of primarily non-linear components used to provide information on reference data, and
10 consequently these systems drift continuously in time with temperature and current.

The object of the present invention is to provide an antenna arrangement of the aforesaid kind which will solve the
15 problem of continuously tracking a moveable signal source that is located above the horizon from a mobile antenna arrangement that is mounted on a moving object at a reasonable cost, i.e. at a cost which is substantially lower than what can be achieved at the present time.

20

SUMMARY OF THE INVENTION

In the case of an antenna arrangement of the aforescribed kind that includes a signal converter and computing unit, it
25 is proposed in accordance with the invention that the signal converter is adapted to reduce its bandwidth automatically and incrementally, wherewith a given bandwidth is activated and retained until a desired input signal can be detected within said bandwidth. The inventive antenna arrangement
30 includes a system of sensors for sensing undesired changes in the alignment of the antenna reflector on the one hand and for setting and retaining a desired antenna position relative to a target object on the other hand; a group of sensors placed on the rear side of the reflector, and a further group
35 of sensors placed on respective rotational axles. Both sensor groups are adapted to be set to zero when an optimal signal detection is achieved thereby that the frequency range of the

signal converter is subjected to incremental reduction from one given bandwidth to the next lower bandwidth until the best possible signal value has been obtained.

- 5 The sensor system provides information relating to changes in the position of the antenna arrangement caused by external forces. This positional change is defined on the basis of speed data (ΔV_x ; ΔV_y ; ΔV_z) which are integrated in a computing unit to obtain relative positional data. With knowledge of
10 the data relating to the speed changes that have occurred within an established time period, determined by the report time of the sensor system, the aforesaid information can be used as the input values for a superordinate computerised system control unit which sends these values to a drive unit
15 for compensating for changes in the position of the antenna arrangement caused by said external forces.

- In this regard, the sensor system can be used for at least two different purposes, such as to compensate for the
20 external forces acting on the antenna arrangement as a result of movement of the surface on which the antenna arrangement is mounted, and also to detect a predetermined desired and allocated movement pattern of the antenna reflector and its tracking of a signal target that has a known orbit and/or a
25 movement pattern calculated with the aid of the computing unit during an ongoing period of time.

- The sensor system thus has overall responsibility for the ability of the antenna arrangement to compensate continuously
30 for the influence of all external forces on said arrangement.

- Correspondingly, it is important to obtain correct compensation data for the temperature dependency, ageing, etc., of the electronic components included in said arrangement, which
35 may otherwise generate system drifts with respect to output data from all electronic components included in the system.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail with reference to the accompanying drawings, in which

5

Fig. 1 illustrates an inventive antenna arrangement; and

Fig. 2 is a block schematic illustrating a signal detection unit and sensor system detection units for movement compensation, included in the antenna arrangement.

10

DESCRIPTION OF PREFERRED EMBODIMENTS

The antenna arrangement illustrated in Fig. 1 includes an antenna reflector 10, a transceiver horn 11 attached to the rear side of the reflector via an arm 110, a signal detection unit 12 and sensor unit 13 having sensors 131, 132, 133 (see Fig. 2) for three-dimensional detection of reflector movement, these two units also being attached as a combined unit to the rear side of the reflector 10. The sensors are adapted to detect movement around respective rotational axles caused by the influence of external forces.

15

20

25

30

35

The transceiver horn is suitably of the kind apparent from Swedish Patent Specification 9402587-1, "Feed Horn Intended Particularly for Two-Way Satellite Communications Equipment". The antenna reflector 10 is anchored mechanically to a base element 16 which, for instance, is anchored to a ship or to a vehicle and which includes a drive or power unit 15 having motors 151, 152, 153, 154 for mechanically controlling the alignment of the antenna reflector 10 with the intended target, e.g. a satellite, in response to control signals generated by a computing unit 123 included in the signal detection unit 12. The antenna reflector 10 and the transceiver horn 11 are combined to form a compact antenna unit suitably constructed in the manner apparent from Swedish Patent Specification 9702268-5, "A Device Comprising an Antenna Reflector and Transceiver Horn Combined in a Compact Unit".

The block schematic of Fig. 1 shows the signal detection unit 12 with series-coupled high-frequency signal converter 121, intermediate frequency signal converter 122 and the computing unit 123. Also shown is the movement detection unit 13 of the sensor system for the antenna reflector, including speed sensors and acceleration sensors for detection in three dimensions (ΔV_x , ΔV_y , ΔV_z) and (Δa_x , Δa_y , Δa_z) working with fibre optics and semiconductor elements respectively. All electronic equipment is subject to drift and instability in time. This requires more or less continuous correction in order to eliminate output data errors. The proposed signal detection unit 12 enables the requisite correction data to be produced for all sensors of the sensor system. -The output side of the high frequency converter 121 is connected to the intermediate frequency part 122, where said automatic reduction in bandwidth is arranged to take place.

The transceiver horn 11 has signal outputs connected to signal inputs on the high-frequency signal converter 121, and the movement detection unit 13 of said sensor system for detecting movement of the antenna reflector has signal outputs connected to signal inputs on the computing unit 123, via conductors 130. The computing unit has outputs connected to the system control 14, which is connected on the output side to the drive unit 15. Thus, in principle, the computing unit 123 is connected on its output side to the input on the drive unit 15 that includes control motors 151-154 for transferring rotational movements to the moveable parts of the antenna arrangement.

The signal output 170 of a second movement detection unit 17 having sensors 171-174 is connected to the signal input 1240 of a second computing unit 124 having a signal output 1241 connected to the signal input 140 of the system control unit 14. The system control unit has a signal input 141 connected to a signal output 1231 on the computing unit 123 and a signal output 142 connected to a signal input 150 on the drive unit 15.

A third movement detection unit 18 having sensors 181-184 intended for detecting actual movement compensation effected in respect of each rotational axis y, x, z, p within the arrangement as a result of compensation data initiated via the system control unit 14, has a signal output 180 connected to a signal input 1250 on a third computing unit 125 that has a signal output 1251 connected to a signal input 143 on the system control unit 14.

The antenna reflector is initially aligned roughly with the target, with the aid of sensors which function to determine the latitude and longitude of the position in question (GPS), an inclinometer and compass. At the same time, the effect of external forces acting on the antenna as the antenna reflector is aligned roughly with the target are compensated for continuously. This movement compensation is effected by the movement detection unit of the sensor system for the different rotational axes of the compact antenna unit (azimuth z, elevation y, elevation x, polarisation pol).

The target is assumed to deliver a pilot frequency of, e.g., 12.541 GHz with a certain drift in the range of ± 40 kHz. The intermediate frequency signal converter 122 is set for a maximum frequency range of ± 8 kHz. The signal detection unit 12 is adapted to operate at the maximum value of the incoming signal (peak, signal curve target = 0). Immediately this maximum value is encountered, (ΔV_x ; ΔV_y ; ΔV_z) and (Δa_x ; Δa_y ; Δa_z) are read-off for new corrected input values and sent to the system control 14, whilst, at the same time, the intermediate frequency signal converter 122 automatically reduces its frequency range to the next lower level, e.g., 3.75 kHz. Meanwhile, the pilot frequency may have drifted slightly and the antenna support surface may have been moved in some direction, (for instance as a result of external forces acting on said support surface and therewith also on the antenna arrangement), but scanning now takes place within

a narrower bandwidth and thereby with reduced incoming signal noise, so that the signal is detected more accurately.

5 The frequency range may optionally be further reduced to a lower level of 1.9 kHz, for instance. At each maximum value there is obtained, in the same way, a new output value from the movement detection unit 13 of the sensor system.

10 The advantage with this automatic "scaling" to the nearest lower selected bandwidth, controlled on the basis of the obtained and detected pilot frequency, is that signal noise is heavily suppressed, since less and less signal noise in relation to the amplitude (peak value) of the pilot frequency is allowed to disturb the detection of the pilot frequency.

15 If the pilot frequency should be lost within the scaling range, the scan returns to the nearest higher bandwidth.

20 Because the proposed signal detection procedure requires time to obtain a stable measuring result, it is imperative that the internal drift and instability of the superordinate sensor system and its movement detection unit are very slight in time, in order for the system to have time to provide a good signal detection result and therewith enable the drift and instability of all system components to be corrected. An
25 essential basis for the cost efficiency that characterises the performance of the inventive antenna arrangement and the limited requirement of costly components lies in allowing the sensor system to have a superordinate role in relation to the signal detection unit, the main purpose of which is to correct
30 the output data of the movement detection unit with respect to component drift and instability.

35 Only those units that are necessary in explaining the concept of the invention have been included in the description. Naturally, the antenna arrangement will also include those units that are normally included and that are necessary for

commercial communications equipment via a satellite, for instance. The 3D-sensors 131-133 of the superordinate movement detection unit which are mounted in the same instrument casing as the signal detection unit 12 on the antenna reflector 10 together with the sensors 171-174 and the sensors 181-184 mounted on respective rotational axles, all send continuously correction data to the drive unit 15 via the system control 14 with a periodicity of less than 15 ms.

10 The equipment can be supplemented with a third 3D-sensor unit for certain applications, this third unit then being mounted on the support base. This provides greater resolution of output data (ΔV_x ; ΔV_y ; ΔV_z) and (Δa_x ; Δa_y ; Δa_z) and enables the mechanical flexibility of the antenna arrangement to be
15 measured dynamically and continuously and the undesired movements within said arrangement to be corrected.

When the signal detection unit 12 has detected a relevant pilot signal from individual measuring horns in the receiver
20 horn 11 and therewith calculated correction data and sent this data with a periodicity of less than 92 ms, a sufficiently good correction of the current position of the antenna arrangement can be initiated. This implies that the output data of the signal detection unit 12 is used as a so-called "true value", wherewith the output data values of the
25 movement detection unit 13 are noted. In this regard, the movement detection unit 13 again assumes the superordinate function regarding the compensation data for forces acting externally on the antenna arrangement.

30 The aforesaid interaction takes place continuously and enables the use of a signal detection unit that has a variable bandwidth, therewith enabling a very narrow bandwidth to be used for optimum direction correction based on a stable but
35 relatively weak pilot signal. The narrow bandwidth enables the detection of very weak pilot signals that would normally be drowned in ambient signal noise at larger bandwidths. This

is made possible by the stable superordinate function of the sensor system over time.

5 The sensor system of the antenna arrangement further includes a number of sensors, namely an inclinometer with associated digital compass, that is mounted in direct connection with the base support of the arrangement above the interface of mounted shock and vibration dampers that separate the other parts of the arrangement from the support base and of joins to the mounting base. The arrangement also includes an external sensor unit consisting of a GPS unit (global positioning system) with associated digital compass. Together with the system control storage data for the programmed positional data of a target object, a theoretically calculated directional value can be obtained with respect to the target object concerned on the basis of the actual geographical position, although not with a higher degree of accuracy than that which can be obtained with the sensor system and its individual sensors. The twin digital compasses enable the sensors, here shown separate, to be calibrated, which means that the compass declination will be smaller than would otherwise be the case. As a result hereof, the method for calculating a directional value to a target object can be said to constitute a rough adjustment. When a gyro compass is available, the compass is connected to the system control and therewith enhances the accuracy of the compass course. This rough adjustment or setting is sufficient for the signal detection unit to find a pilot signal for optimised alignment with the target object.

30 When a gyro compass cannot be used because of environmental conditions, a bearing can be obtained with the aid of the inclinometer and the known elevation to the target transmitter. As the antenna rotates and the signal data is analysed by a broadband spectrum analyser, a unique transmitter combination is able to establish identity and thereby the bearing concerned.

The movement detection unit 13 and the movement sensors mounted on respective axles continuously transmit compensation data for those forces acting externally on the antenna arrange-

ment during the whole of the introductory phase and continue to transmit said data so as to maintain the horizontal plane indicated by the inclinometers, which naturally also constitutes a prerequisite for setting the desired height of elevation to the target object. (If this is not adequately achieved, it cannot be safely assumed that the signal detection unit 12 has reached its detection range of ± 2 degrees of angle).

At the same time, there is continuously received information relating to the difference between calculated, initiated compensation data, so-called "set-point values", and actually effected values, so-called "true values", through the medium of the sensors 181-184.

As will be apparent from the foregoing, it is of utmost importance to invest in quality with respect to the individual sensor units, and then mainly on the 3D-sensors (V_x ; V_y ; V_z) and (a_x ; A_{ay} ; a_z) and 2D-inclinometers (x ; y) on which the antenna arrangement depends.

The choice of digital components minimises the risk that external signal disturbance signal source will have a negative effect on the function of the antenna arrangement. CAN-Bus technology is able to render the arrangement less sensitive to disturbances and interference and to render said arrangement cost-effective, although it will be understood that this technology is not a prerequisite of the invention.

The illustrated and described exemplifying embodiment of the antenna arrangement is said to include a transceiver horn of a certain, specific kind. It will be understood, however, that the invention is not restricted to this kind of transceiver horn. For instance, the antenna element may comprise a so-called patch antenna with microstrip lines placed in the focal plane of a reflector and covering both the absolute focus of the reflector and also its immediate surroundings.

**CLAIMS**

1. An antenna arrangement comprising an antenna reflector (10), a transceiver element (11) and a signal detection unit (12) for processing signals incoming from a target and for generating on the basis of said incoming signals control signals for controlling alignment of the antenna reflector (10) with the target, wherewith the detector unit (12) includes a signal converter (121-122) and a computing unit (123) in series, **characterised** in that the signal converter (121-122) is adapted to reduce said bandwidth automatically and incrementally from a requisite maximum frequency range to a narrow band frequency range, wherein its bandwidth is activated and maintained until a desired input signal can be detected within the bandwidth concerned, thereby achieving the highest detectable sensitivity for said input signal; and in that the antenna arrangement also includes a movement detector unit (13) which includes 3D-sensors (131, 132, 133) and which is adapted to detect changes in the alignment of said antenna reflector (10), wherewith the 3D-sensors are placed on the rear side of the antenna reflector (10) with a signal output (130) connected to a signal input (1230) on the computing unit (123) for generating further control signals; and a drive unit (15) for controlling alignment of the antenna reflector (10) mechanically in response to the external control signals originating from the antenna reflector on the one hand and on the further control signals originating from the movement detector unit (13) on the other hand.
2. An antenna arrangement according to Claim 1, **characterised** by a second movement detector unit (17) having sensors (171-174) intended for detecting position changes of each rotational axle (y, x, z, p) in said arrangement as a result of external forces acting on and within said arrangement, and having a signal output (170) connected to a signal input (1240) on a second computing unit (124) which has a

signal output (1241) connected to a signal input (140) on a system control unit (14) which, in turn, has a signal input (141) connected to a signal output (1231) on the first computing unit (123) and a signal output (142) connected to a signal input (150) on the drive unit (15).

3. An antenna arrangement according to Claim 2, characterised by a third movement detector unit (18) having sensors (181-184) for detecting movement compensation that has been truly effected on each rotational axle (y, x, z, p) within the arrangement in response to compensation data initiated via the system control unit (14), and having a signal output (180) connected to a signal input (1250) on a third computing unit (125) that has a signal output (1251) connected to a signal input (143) on the system control unit (14).

4. An antenna arrangement according to Claim 1, characterised in that the signal converter (121-122) includes a high frequency part (121) whose input side is connected to the receiver side of the transceiver element (11) and whose output side is connected to an intermediate frequency part (122) where automatic reduction of the bandwidth is arranged to take place.

