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**Datasheet for the decision
of 13 July 2006**

Case Number: T 0775/04 - 3.4.01

Application Number: 01922235.5

Publication Number: 1264366

IPC: H01Q 13/02

Language of the proceedings: EN

Title of invention:

Antenna horn and method for making the same

Applicant:

HARRIS CORPORATION

Opponent:

-

Headword:

Antenna horn device with quad-ridge horn

Relevant legal provisions:

EPC Art. 56

Keyword:

"Inventive step (no; for all requests)"

Decisions cited:

-

Catchword:

-



Case Number: T 0775/04 - 3.4.01

D E C I S I O N
of the Technical Board of Appeal 3.4.01
of 13 July 2006

Appellant: HARRIS CORPORATION
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Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 22 January 2004
refusing European application No. 01922235.5
pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: B. Schachenmann
Members: H. Wolfrum
G. Assi

Summary of Facts and Submissions

- I. European patent application 01 922 235.5 (publication No. WO 01/061785 and EP 1 264 366) was refused by a decision of the examining division dispatched on 22 January 2004, on the ground of lack of inventive within the meaning of Articles 52(1) and 56 EPC of an antenna horn device as defined by claims 1 and 2 then on file.
- II. The applicant lodged an appeal against the decision and paid the prescribed fee on 31 March 2004. On 1 June 2004 a statement of grounds of appeal was filed together with a set of new claims 1 and 2.
- III. On 14 February 2006 the appellant was summoned to oral proceedings to take place on 13 July 2006.

In a communication dated 15 May 2006 the Board gave *inter alia* a preliminary view as to the issue of inventive step (Articles 52(1) and 56 EPC). In this context, reference was made to documents:

- D1** : US-A-5 471 664;
D2 : US-A-5 737 698;
D3 : US-A-3 458 862;
D4 : EP-A-0 071 069; and
D5 : US-A-4 999 136.

- IV. In response the appellant filed by letter of 13 June 2006 three sets of claims as first to third auxiliary requests, respectively.
- V. Oral proceedings were held on 13 July 2006.

As a result of the discussion, the appellant requested that the decision under appeal be set aside and a patent be granted on the basis of new sets of claims filed in the oral proceedings according to a main request and first to eighth auxiliary requests, respectively.

VI. Claim 1 of the appellant's **main request** reads as follows :

"1. A dual polarized antenna horn device comprising:
- an electrically conductive conduit (40) having first and second opposite ends along the antenna horn axis,
- a printed wiring board (28) including a dielectric substrate (32) connected across the first end of said antenna horn (26) and transversely to the antenna horn axis, and having an electrically conductive pattern (50) formed on the dielectric substrate (32) defining feed elements (52,53) for said antenna horn (26), which are positioned orthogonal to each other and which are connected to antenna electronics (56),
- said electrically conductive pattern (50) comprising portions (54) corresponding to the electrically conductive conduit (40), and including a first side conductive pattern on a first side of said dielectric substrate (32) and a second side dielectric [sic!] pattern on a second side of said dielectric substrate (32),
- said first side conductive pattern being connected by means of a plurality of through-holes (60) in said dielectric substrate (28) to said second side conductive pattern,

characterized in that

- *said antenna horn (26) is a quad-ridge antenna horn having four electrically conductive ridges (42) extending longitudinally on an inner side of said electrically conductive conduit (40),*
- *said electrically conductive pattern (50) further comprising portions (54) corresponding to the four ridges (42) of the antenna horn (26), and*
- *said conductive conduit (40) and the four ridges (42) are connected to said corresponding portions (54) of said conductive pattern (50) with an electrically conductive adhesive (64)."*

Claims 2 to 14 are dependent claims.

Claim 1 of the appellant's **first auxiliary request** differs from claim 1 of the main request in that it is additionally specified in the last feature that the conduit (40) and the four ridges (42) are connected to said corresponding portions (54) of said "*first side*" conductive pattern.

Claims 2 to 13 are dependent therefrom.

Claim 1 of the appellant's **second auxiliary request** differs from claim 1 of the main request in that it is additionally specified in the last feature that the conduit (40) and the four ridges (42) are connected to said corresponding portions (54) of said conductive pattern (50) "*on a side of the dielectric substrate (32) opposite to the side where the feed elements (52, 53) are*".

Claims 2 to 12 are dependent therefrom.

Claim 1 of the appellant's **third auxiliary request** is based on claim 1 of the second auxiliary request and additionally specifies that

"said portions (54) are included in said first side conductive pattern and said second side conductive pattern; and

said through holes (60) connect the portions (54) on opposite sides of the dielectric substrate (32)" and that

"said feed elements (52,53) extend through portions (54) of said conductive pattern (50) corresponding to two of said electrically conductive ridges (42), which are orthogonal to each other".

Claims 2 to 9 are dependent therefrom.

Claim 1 of the appellant's **fourth auxiliary request** corresponds to claim 1 of the third auxiliary request and additionally specifies that the feed elements

"connect to portions (54) of the conductive pattern (50), which correspond to electrically conductive ridges (42) and that are, respectively, opposite to the portions (54) through which the feed elements (52, 53) extend".

Claims 2 to 8 are dependent therefrom.

Claim 1 of the appellant's **fifth auxiliary request** is based on claim 1 of the fourth auxiliary request and still further specifies that *"the conductive pattern (50) includes input/output tabs (58) for interfacing with connectors and/or an antenna control unit (22)".*

Claims 2 to 7 are dependent therefrom.

Claim 1 of the appellant's **sixth auxiliary request** is based on claim 1 of the third auxiliary request and

additionally specifies that "*said second side conductive pattern (50) includes input/output tabs (58) for interfacing with connectors and/or an antenna control unit (22)*".

Claims 2 to 9 are dependent therefrom.

Claim 1 of the appellant's **seventh auxiliary request** is based on claim 1 of the third auxiliary request and additionally specifies that "*said second side conductive pattern (50) includes input/output tabs (58) for interfacing with connectors and/or an antenna control unit (22), which is arranged so as to face the second side conductive pattern*".

Claims 2 to 9 are dependent therefrom.

The only claim of the appellant's **eighth auxiliary request** is directed to "*A phased array antenna, in which the relative phases of the respective feeding signals of antenna horns are varied to scan a beam in a desired direction*" comprising "*at least two electrically conductive conduits (40)*" (ie antenna horns) and a (common) printed wiring board, the antenna horns and the printed wiring board having in combination the features specified in claim 1 of the seventh auxiliary request.

VII. In support of inventive step for the subject-matter of its requests, the appellant argued in essence that none of the documents of the available prior art taught the skilled person how to devise a quad-ridge horn antenna which was easy to manufacture and showed excellent efficiency for operation in a wide band of high frequencies. Key features in this respect were the realisation of the required high frequency feeding

circuitry in printed circuit technology in combination with the provision of a systematic high frequency grounding as well as a highly efficient coupling of high frequency energy into the antenna horn. This was achieved by a specific layout of the conductive pattern, which comprised, on both sides of the wiring board, portions corresponding to the conduit and the ridges of the horn and thus replicating the footprint of the horn structure, by means of conductive through-holes interconnecting said portions of the conductive pattern, and by a specific arrangement of feed elements within the conductive pattern. Moreover, the use of conductive adhesive for establishing the electrical bonding of the antenna horn to the wiring pattern complemented a thorough high-frequency grounding while allowing for larger fabrication tolerances and further simplifying manufacturing of the antenna device. Furthermore, two orthogonal feed elements crossing at the centre of the horn's conduit brought about a superior wave matching for a highly efficient energy coupling into the horn, and the provision of input/output tabs for interfacing with an antenna control unit rendered any lateral connectors superfluous and hence the antenna horn device particularly suitable for integration within a phased array antenna.

None of the antenna devices known from documents D1, D2 and D4 had a quad-ridge horn. The cylindrical horns of the known antennas operated in frequency bands which were narrower than that of a quad-ridge horn antenna. Although the feeding circuits of these devices were implemented in printed circuit technology, their specific layouts were not suitable for efficient wide band energy coupling into a quad-ridge horn. Thus, the

skilled person did not have a feeding circuitry at its disposal as was required for wide band operation of quad-ridge horn antennas.

D3, the only document on file which concerned a quad-ridge antenna device, taught feeding by means of coaxial cables. The use of cables and associated connectors was difficult to automate and rendered fabrication of an array of horns particularly difficult. On the other hand, the skilled person had no incentive to abandon the perfect high frequency ground shielding inherent to coaxial cables in favour of printed wirings inherently providing a poorer shielding. But even if the skilled person had considered to replace cable feeding by printed circuit technology, he would not have known, in the absence of any example in the available prior art, how to devise the claimed circuit layout.

Finally, the prior art would not have taught the skilled person that, by using a conductive adhesive for securing the antenna horn to the conductive pattern, the antenna device not only became easier to manufacture but, in combination with the conductive through-holes, also high frequency grounding could be improved.

Reasons for the Decision

1. The appeal complies with the requirements of Articles 106 to 108 and Rule 64 EPC and is, therefore, admissible.

A. Main request

2. *Amendments*

In its communication the Board raised the question whether the specific combination of features claimed by claim 1 on file had a basis of disclosure in the originally-filed application documents and thus whether the amendment made would comply with the requirements of Article 123(2) EPC. However, for the purpose of this decision the Board defers respective doubts.

3. *Inventive step (Articles 52(1) and 56 EPC)*

- 3.1 As document D3 is the only document on file concerning a quad-ridge antenna horn, it is considered as a reasonable starting point for evaluating inventive step in the present case.

Document D3 (see in particular Figures 2 to 6 with the corresponding description) discloses a dual polarized quad-ridge antenna horn device with an electrically conductive conduit (21) having first and second opposite ends along the antenna horn axis and with four spaced apart electrically conductive ridges (22a,b - 25a,b; 32a,b - 35a,b) extending longitudinally on an inner side of the electrically conductive conduit (21). As can be seen from Figure 3, the ridges end in a common cross-sectional plane within the conduit (21) forming the throat of the horn. For feeding energy into the antenna horn, two orthogonal feed elements in the form of coaxial lines (41 and 42) are brought into the same cross-sectional plane (column 4, lines 44 to 46). A termination chamber (44) provides for proper coupling

- of the coaxial lines. The outer conductors of the coaxial lines are respectively connected to two of said electrically conductive ridges which are orthogonal to each other. Each of the inner conductors of the coaxial lines extends without contact along a respective one of these two orthogonal ridges and connects respectively to an opposite ridge (column 4, lines 46 to 55).
- 3.2 The subject-matter of claim 1 under consideration differs from the antenna device known from D3 mainly in that the necessary feeding circuit is implemented in printed circuit technology and that the horn with its conduit and ridges is connected to corresponding portions of a printed circuit pattern on both sides of a printed wiring board by means of an electrically conductive adhesive and via conductive through-holes.
- 3.3 The Board concurs with the appellant that the objective problem associated with these differences is to be seen in the desire to decrease the size requirements for a dual-polarized quad-ridge horn while, at the same time, easing micro-assembly and automated manufacture and preventing variable RF characteristics (see point 1.8 of the statement of grounds of appeal).
- 3.4 In the Board's view, reducing the size of electronic devices and simplifying their fabrication belong to the normal tasks of a skilled person who, in the present case, has the qualification of an electronic engineer working in the field of high frequency antenna devices. Thus, recognizing the aforementioned problem does not, as such, involve any inventive activity.

3.5 Moreover, employing printed circuit technology for establishing the feeding circuitry of high frequency antenna horn devices is a well known measure in the art, as is evidenced by each of documents D1, D2 or D4.

In this respect, document D1 (see in particular Figures 1 and 2 with the corresponding description) refers to a circularly polarized wave receiving device which comprises an antenna horn with a cylindrically shaped conduit secured to a printed circuit board and electrically coupled to an annular strip-shaped conductive ground pattern formed on the board's dielectric substrate and connected to another ground pattern on the back side of the dielectric substrate. The ground patterns correspond to the footprint of the horn's conduit and are electrically interconnected by means of a plurality of through-holes in the substrate (column 2, lines 22 to 28). The conductive pattern further includes orthogonally arranged input probes, *ie* feed elements (22 - 25) which are formed on the back side of the substrate, extend there through the ground pattern and are connected to feed lines (18,19) of the antenna electronics.

Similar antenna devices are known from document D2 (see in particular Figures 3 to 5 and 7 to 10 with the corresponding description) and, with the exception of through-holes, from document D4 (see in particular Figures 2 and 3 with the corresponding description). These documents expressly deal with antenna horns arranged on printed circuit boards and with the advantages associated with orthogonal feed probes in coplanar printed circuit technology in terms of a compact, simple, reliable and inexpensive alternative

to microwave cabling which facilitates assembly avoiding connectors and at the same time reduces noise figure (see column 2, lines 23 to 30 and 45 to 59 in D2; page 2, lines 3 to 31 in D4).

- 3.6 In the light of the teaching of any one of documents D1, D2 or D4, it would have been obvious for the skilled person at the priority date of the present application to consider replacement of the coaxial feed cables of the antenna device of D3 by a feeding circuitry on a printed circuit board as being a viable option which promised simplified manufacturing and enhanced electrical performance.

In this situation, the skilled person would have been aware of the fact that the specific circuit layouts shown in any one of documents D1, D2 and D4 for antenna horns without ridges need adaptation to the different footprint of the antenna horn of document D3 in order to safeguard efficient coupling of high frequency energy. In fact, it would have been unreasonable for the skilled person to retain unchanged any one of the known circuit layouts devised for horns having no ridges for a quad-ridge horn structure, as suggested by the appellant.

Thus, the main task the skilled person would have been faced with is indeed that of devising an appropriate layout for the conductor pattern which forms the feed elements and establishes the required high frequency grounding. In this regard, an evident measure for the skilled person is the replication of the feed structure known for the quad-ridge horn antenna from document D3 in planar printed circuit technology by appropriately

modifying the circuit layouts for the feed elements and the high frequency grounding shown in particular in any one of documents D1 and D2. This approach would immediately have led the skilled person to devise a conductive pattern comprising, on both sides of the substrate, portions which correspond to the conduit and the four ridges of the antenna horn and are interconnected by through-holes and further defining, on the side opposite the side to which the horn is secured, feed elements positioned orthogonal to each other and connected to antenna electronics.

3.7 Finally, as regards the choice of a suitable technique of electrically connecting the quad-ridge horn to the conductive pattern of the printed circuit board, conductive adhesives were known to be particularly advantageous for connecting electric components to printed circuit boards as a replacement for solder, as is evidenced for instance by document D5 (see column 3, lines 38 to 52). Therefore, no inventive skill would have been required for the skilled person to make use of known advantages, eg in terms of low temperature bonding, associated with certain conductive adhesives when contemplating bonding of a quad-ridge antenna horn to a printed circuit board.

3.8 The appellant argued that the cited prior art documents not only failed to disclose a high frequency feeding circuit in printed circuit technology suitable for broad band operation of a quad-ridge horn but even dissuaded the skilled person from contemplating the claimed combination of a quad-ridge antenna horn with printed circuit technology for the feed elements and high frequency grounding. In the absence of any example

in the prior art of the necessary circuit layout, there was a risk with planar wiring of energy loss and uncontrolled high frequency emission due to an imperfect ground shielding. Moreover, no teaching existed as to how an efficient wide band coupling of energy into a ridge structure could be achieved.

These arguments did not convince the Board. In particular, the argument, that the skilled person would not have abandoned the high frequency feeding of the quad ridge horn of document D3 by a coaxial cable because it promised perfect high frequency grounding, is at odds with the known facts that cabling increases the noise figure for an amplifier connected to the antenna (D2 : column 2, lines 23 to 30) and that high frequency operation of antennas puts high demands on the accuracy of manufacturing of cables and connectors to be used, thus rendering their use complex and expensive (D4 : page 2, lines 3 to 6).

Moreover, the allegation that, although showing some aspects of the claimed solution, the prior art did not contain any motivation for the skilled person to combine these aspects in a quad-ridge antenna horn device is at variance with the extensive presentation of advantages associated with printed circuit feeding of antenna horns given in particular in documents D2 and D4.

Finally, the submission that the teaching of document D5 was not specific as to the use of conductive adhesive for establishing bonding between high frequency components, where even minor differences in the electrical conductivity would have deleterious

effects, disregards the evidence provided in particular by Figures 3 and 4 of D5 according to which bonding by conductive adhesive was in no way inferior to solder bonding in terms of absolute values and variations of the resistivity of the bond.

- 3.9 In summary, starting from document D3, it was obvious for the skilled person to make use of printed circuit technology known from document D1 or D2 by accordingly adapting the circuit layout to the footprint of a quad-ridge horn antenna and, independently thereof, to use the connecting technique known eg from document D5. Consequently, the Board has come to the conclusion that no exercise of inventive skill would have been required for the skilled person to devise a dual polarized antenna device as defined by claim 1 of the main request.

Therefore the main request does not comply with the requirements of Articles 52(1) and 56 EPC and, consequently, is not allowable.

B. Auxiliary requests

4. The amendments made to claims 1 of the first and second auxiliary requests, defining the allocation of the antenna horn and the feed elements to the two sides of the printed circuit board, concern construction features which are known from any one of documents D1, D2 and D4, as is apparent from the discussion in point 3.5 above.

The further amendments made to claims 1 of the third and fourth auxiliary request specify details of the

- arrangement of the feed elements with respect to the ridges which correspond to the feeding circuitry for the quad-ridge horn antenna known from document D3 (see point 3.1 above), and define structural features of the high frequency grounding pattern which are known from each of documents D1 and D2 (see point 3.5 above).
5. The amendments made to claims 1 of the fifth to seventh auxiliary request refer to the provision of input/output tabs for interfering with connectors and/or an antenna control unit.
- 5.1 The appellant submitted that the arrangement of such tabs at the side of the board opposite the antenna horn avoided the provision of bulky lateral connectors as shown for instance in Figure 2 of document D4 and allowed for a compact arrangement of an antenna control unit at the back of the device which was particularly suitable for an array of antenna horns. None of the prior art documents hinted at such a structure.
- 5.2 This argumentation ignores the circumstance that the claimed features by no means limit the respective claims 1 to the envisaged compact structure, so that even the arrangement of a connector as shown in Figure 2 of document D4 would fall within the terms of the added features. Apart from the phrase "*The conductive pattern (50) may include input/output tabs (58) for interfacing with connectors and/or an antenna control unit (22)*" and the drawings of Figures 1 to 3, showing a control unit 22 arranged in the vicinity of a protector plate or PWB housing 30, no information is disclosed in the originally-filed application documents as regards the arrangement of connectors or a control

unit with respect to or within the antenna device. Thus, no additional effect can be seen which could justify inventive step.

Moreover, appellant's submission disregards the fact that input/output tabs for connecting printed circuits to outside circuitry are commonplace in the art, as is for instance evidenced by document D2 (see signal line end 106 in Figure 4 and connector 30 in Figures 1 to 3; and column 5, lines 21 to 23).

6. The still further amendments made to claim 1 of the eighth auxiliary request concern a way of operating a phased array antenna formed from an array of horn antennas which belongs to the common knowledge of the skilled person as defined above.

7. As shown above, the amendments made to the first to eighth auxiliary requests only concern measures which are either well known in or rendered obvious by the same prior art as is taken into consideration for the subject-matter of the main request. Thus, the amendments cannot be regarded as adding inventive matter within the meaning of Articles 52(1) and 56 EPC for the same reasons as set out for main request.

Therefore, none of the auxiliary requests is allowable either.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar

The Chairman

S. Sánchez Chiquero

B. Schachenmann