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Published
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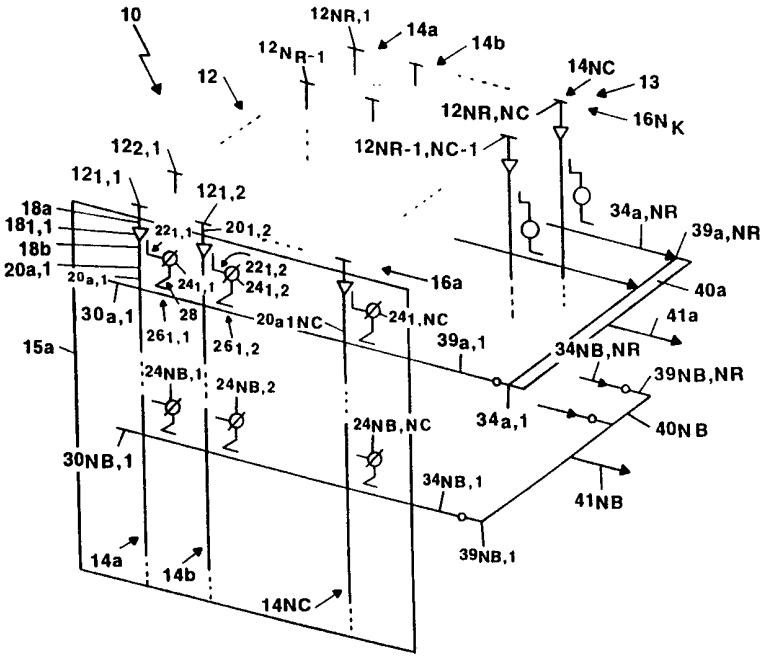
7 October 1999 (07.10.99)

(54) Title: ARRAY ANTENNA HAVING MULTIPLE INDEPENDENTLY STEERED BEAMS

(57) Abstract

An array antenna system for forming a plurality (e.g. 64) independently steered beams comprising an array of antenna elements (12), a first and a second plurality of series feed signal paths (20, 26), a plurality of phase shifters (24), a first and a second plurality of couplers (22, 26) and a signal combiner (40) for forming the respective beams, e.g. pencil beams. The array antenna system may be formed as a two–dimensional electronically controlled phased array antenna system (10) providing a planar array antenna (13) with N_C array columns (14) and N_R array rows (16) comprising patch, waveguide, dipole or slot elements. Each of the first plurality of series feed signal paths (20) is coupled to one of the antenna elements (12) and each of the plurality of phase shifters (24) has a first and a second phase shifter port. Each first phase shifter port couples a signal from a corresponding antenna element (12) via a corresponding one of the first plurality of series feed signal paths (20) to a corresponding one of the first plurality (22) of couplers. Each second phase shifter port couples a signal via a corresponding one of the second plurality of series feed signal paths (30) to a corresponding one of the second plurality (26) of couplers. A signal combiner (40) combines the signals to provide one or more antenna beams. Moreover, a first plurality of parallel feed signal paths may be used as well which may be provided as corporate power dividers or series feed lines and signal combiners to provide both receive and transmit array antenna systems. In a particular embodiment a beam/element grid junction is proposed for use in a phased array antenna.



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INTERNATIONAL SEARCH REPORT

Intern. ..nal Application No
PCT/US 99/00141

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01Q25/00 H01Q21/06 H01Q21/00 H01Q21/22 H01Q3/26 H01Q3/40

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 6 H01Q

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	EP 0 834 955 A (HAZELTINE CORP) 8 April 1998	1-6
P,X	see page 2, line 3-58; claims 1-14; figures 1-5	1,6

X	EP 0 727 839 A (SPACE ENGINEERING SPA ;ALENIA SPAZIO SPA (IT)) 21 August 1996 see column 2, line 10 - column 3, line 21; claims 1-5; figures 1-6	1-10

A	EP 0 801 437 A (TRW INC) 15 October 1997 see column 4, line 34 - column 8, line 44; figures 1-12 see column 1, line 11 - column 2, line 57; figures 13,14 see abstract	1-10

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 April 1999	26.07.99

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Felgel-Farnholz, W-D

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 99/00141

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-10

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

1. Claims: 1-10

The first independent Claim 1 defines an array antenna system for forming multiple independently steered beams, comprising an array of antenna elements, two pluralities of series feed signal paths, a plurality of phase shifters, two pluralities of couplers and a signal combiner.

2. Claims: 11-13

The second independent Claim 11 defines an array antenna for providing multiple independently steered beams, comprising a plurality of antenna elements, a plurality of phase shifters, a plurality of coporate power dividers and a corporate combiner.

3. Claims: 14-18

The third independent Claim 14 defines an RF circuit comprising two directional couplers and a phase shifter.

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern. ...nal Application No
PCT/US 99/00141

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0834955 A	08-04-1998	US 5856810 A	05-01-1999
EP 0727839 A	21-08-1996	US 5548295 A	20-08-1996
EP 0801437 A	15-10-1997	US 5760741 A	02-06-1998
		JP 10065441 A	06-03-1998