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 H01Q 21/10 (2006.01)</p> | <p>(81) Designated States <i>(unless otherwise indicated, for every kind of national protection available):</i> AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.</p> |
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[Continued on next page]

- (54) Title: MULTIPLE ANTENNA SYSTEM

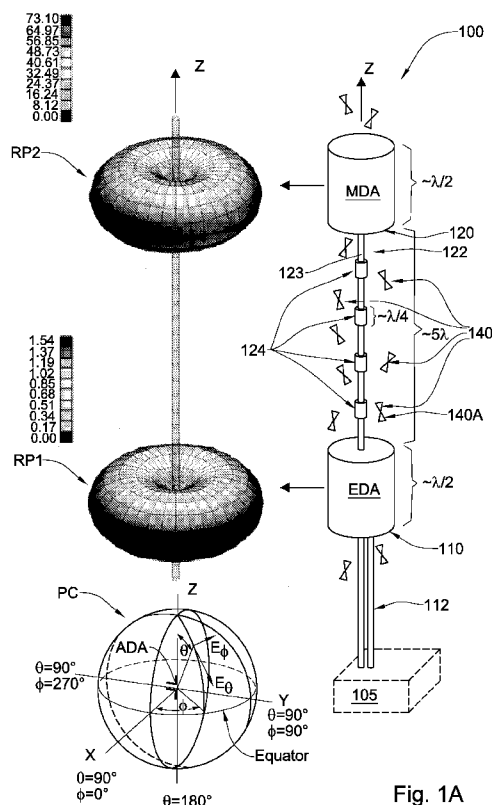


Fig. 1A

- (57) Abstract:** The present invention relates to an antenna system (100) including at least two antenna modules (110, 120) operable for transmitting and/or receiving radiation in certain common frequency band. The at least two antenna modules (110, 120) are collinearly arranged along a common axis so as to provide low gain along the axis, and are spaced apart from one another along this axis by a distance of at least a few nominal wavelengths of the common frequency band. Each two locally adjacent antenna modules of the at least two antenna modules (110, 120) operate with substantially mutually orthogonal polarizations of radiation, thereby suppressing electromagnetic coupling between the antenna modules in the common frequency band.



Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

INV. H01Q1/52 H01Q21/10 H01Q21/24
ADD.

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)

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/017462 A1 (ANTENOVA LTD [GB]; KINGSLEY SIMON PHILIP [GB]; TYLER SCOTT WILLIAM SPE) 26 February 2004 (2004-02-26) page 15 - page 21; figures 1-6 -----	1,10,11, 13,16, 25,26,28
X	EP 2 178 165 A1 (PANASONIC CORP [JP]) 21 April 2010 (2010-04-21) paragraph [0098] - paragraph [0128]; figures 11-15 -----	16,26,28
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A	EP 0 817 312 A2 (MURATA MANUFACTURING CO [JP]) 7 January 1998 (1998-01-07) abstract ----- -/-	2,17



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"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

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

PCT/IL2013/050116

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2004/032363 A1 (SCHANTZ HANS GREGORY [US] ET AL) 19 February 2004 (2004-02-19) abstract -----	1,2,10, 16,17,25
X	US 5 923 296 A (SANZGIRI SHASHI M [US] ET AL) 13 July 1999 (1999-07-13) page 3, line 45 - line 62; figures 2,3 -----	1,10,11, 13,16, 25,26,28
X	WO 99/13531 A1 (TIME DOMAIN CORP [US]) 18 March 1999 (1999-03-18) Y pages 10-13; figure 8 -----	16,17, 25,26,28 1-15, 18-24, 27,29
Y	US 4 359 743 A (DESANTIS CHARLES M) 16 November 1982 (1982-11-16) column 2, line 54 - column 4, line 60; figures 1-8 -----	1-6, 10-15, 18-21,27
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Y	US 7 369 879 B1 (STEIGERWALD TODD W [US] ET AL) 6 May 2008 (2008-05-06) column 18, line 18 - column 20, line 23; figures 2-7 -----	7-9,14, 22-24,29
Y	GAO Q ET AL: "Application of metamaterials to ultra-thin radar-absorbing material design", ELECTRONICS LETTERS, IEE STEVENAGE, GB, vol. 41, no. 17, 18 August 2005 (2005-08-18), pages 936-937, XP006025026, ISSN: 0013-5194, DOI: 10.1049/EL:20051239 figure 1 -----	8,23
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A	EP 1 768 211 A1 (SAMSUNG ELECTRONICS CO LTD [KR]) 28 March 2007 (2007-03-28) abstract -----	7,22
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INTERNATIONAL SEARCH REPORT

International application No

PCT/IL2013/050116

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2006/227062 A1 (FRANCQUE CRAIG [US] ET AL) 12 October 2006 (2006-10-12) abstract -----	7,22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2013/050116

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 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 No. III Observations where unity of invention is lacking (Continuation of item 3 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 fees, this Authority did not invite payment of additional fees.
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.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1, 2, 10, 11, 13, 16, 17, 25, 26, 28

An antenna system comprising at least two antenna modules having a certain common frequency band of electromagnetic radiation, said at least two antenna modules are collinearly arranged along a common axis so as to provide low gain along said axis; said at least two antenna modules are spaced apart from one another along said axis by a distance of at least a few nominal wavelengths corresponding to said frequency band, each two locally adjacent antenna modules of said at least two antenna modules operate with substantially mutually orthogonal polarizations of radiation, thereby suppressing EM coupling between the antenna modules in said common frequency band, wherein the locally adjacent antenna modules comprise a magnetic dipole (MD) antenna module and an electric dipole (ED) antenna module, each of said MD and ED antenna modules is characterized by a toroidal EM radiation pattern coaxial with respect to said common axis, thereby providing the low gain along said axis..

2. claims: 3-6, 12, 15, 18-21, 27

An antenna system comprising an array of a certain number of antenna modules arranged in a spaced-apart relation along a common axis and comprising the antenna modules of mutually orthogonal polarizations arranged in alternating fashion, such that each two locally adjacent antenna modules are of the mutually orthogonal polarizations, wherein at least one signal feeding module associated with at least one of said two antenna modules, the signal feeding module defining a transmission line passing through the vicinity of the other of said two antenna modules, said feeding module comprising an induced current suppression utility adapted for suppressing noise signals induced on said feeding module by said other antenna module, thereby reducing the EM coupling between said two antenna modules.

3. claims: 7-9, 14, 22-24, 29

An antenna system comprising an array of a certain number of antenna modules arranged in a spaced-apart relation along a common axis and comprising the antenna modules of mutually orthogonal polarizations arranged in alternating fashion, such that each two locally adjacent antenna modules are of the mutually orthogonal polarizations, wherein an arrangement of one or more parasitic antenna circuits is configured and operable for resonating in frequencies corresponding to said frequency band; said one or more parasitic antenna circuits being arranged in the vicinity of said at least two antenna modules for scattering at least

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

some of a residual EM radiation by which said antenna modules are electromagnetically coupled thereby reducing a crosstalk between said antenna modules.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IL2013/050116

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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