(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 890 114 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
06.10.2021 Bulletin 2021/40

(21) Application number: **18918415.3**

(22) Date of filing: **23.11.2018**

(51) Int Cl.:
H01Q 13/20 *(2006.01)* ***H01P 3/06*** *(2006.01)*

(86) International application number:
PCT/CN2018/117275

(87) International publication number:
WO 2020/103150 (28.05.2020 Gazette 2020/22)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Zhongtian Radio Frequency Cable Co., Ltd**
Nantong, Jiangsu 226009 (CN)

(72) Inventors:
- **LIN, Longlong**
  Nantong, Jiangsu 226009 (CN)
- **ZHAO, Ruijing**
  Nantong, Jiangsu 226009 (CN)
- **LAN, Yanrui**
  Nantong, Jiangsu 226009 (CN)
- **WANG, Bin**
  Nantong, Jiangsu 226009 (CN)
- **XU, Zongming**
  Nantong, Jiangsu 226009 (CN)
- **XU, Bohua**
  Nantong, Jiangsu 226009 (CN)
- **HUANG, debing**
  Nantong, Jiangsu 226009 (CN)

(74) Representative: **Zaboliene, Reda**
Metida
Business center Vertas
Gyneju str. 16
01109 Vilnius (LT)

(54) WIDE-ANGLE RADIATION LEAKY COAXIAL CABLE

(57) The present disclosure provides a wide-angle radiating leaky cable, from inner side to outer side, including an inner conductive body, an insulating layer, an outer conductive body, and an outer protective casing. A plurality of sections of slots are defined on wall of the outer conductive body, the sections of slots are equally spaced apart from each other. Each section of slots is composed of a plurality of slot modules. Each slot module includes a plurality of slot units independent from each other. The wide-angle radiating leaky cable of the present disclosure obtains wide-angle radiating through a distributed leakage mode. By including a plurality of independent slot units in each slot module, the problems of a small slot, a weak intensity of low-frequency radiation, and a narrow radial radiation angle at high frequency resulted from a high-frequency signal coverage, can be overcome. The slot unit of a specific design can reduce high-frequency attenuation, so that the leaky cable can be compatible with low-frequency coupling and high-frequency attenuation, has a good signal combining ability, and greatly reduce the cost of indoor signal coverage.

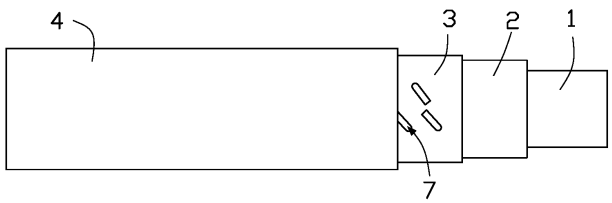

FIG. 1

EP 3 890 114 A1

Description

FIELD

[0001] The subject matter herein generally relates to the field of cables, and more particularly, to a wide-angle radiating leaky cable.

BACKGROUND

[0002] This section is intended to provide background or context for the embodiments of the present disclosure set forth in the claims. Descriptions related herein are not admitted to be prior art by being included in this section.

[0003] Leaky cables have both a signal transmission function and an antenna radiation function. The leaky cable can wirelessly communicate with external space through slots defined at the outer conductive body. The leaky cable has the advantages of uniform signal coverage and easy installation. Thus, the leaky cable is widely used in wireless communication systems installed in narrow spaces such as tunnels, mines, subways, adits, and also high-speed trains and indoor buildings, and has a very broad development prospect. When covered by wireless network, because the indoor environment is complicated, a larger radial radiation angle of the leaky cable is needed to eliminate the signal dead zones to obtain a uniform signal coverage.

[0004] With the development and frequently use of communication technology, to meet the requirement of high-frequency signals, the slot size of the leaky cable becomes smaller. Therefore, the radial radiation range of the leaky cable at high frequency also becomes smaller, thus the leaky cable cannot meet the requirement of indoor wide-angle coverage by eliminating the signal dead zones. At the same time, when the frequency band becomes wider, the existing slot becomes incompatible with low-frequency coupling and high-frequency attenuation. Thus, the cost of indoor signal coverage is increased.

SUMMARY

[0005] What is needed, is a wide-angle radiating leaky cable which has a wide radial radiation angle of 170 degrees or more, small coupling loss, good compatibility with high frequency and low frequency, large radial signal coverage, and high uniformity.

[0006] The present disclosure provides a wide-angle radiating leaky cable, from inner side to outer side, including an inner conductive body, an insulating layer, an outer conductive body, and an outer protective casing. A plurality of sections of slots are defined on wall of the outer conductive body, the sections of slots are equally spaced apart from each other. Each section of slots is composed of a plurality of slot modules. Each slot module includes a plurality of slot units independent from each other.

[0007] Furthermore, each slot unit 8 has a length of 1 to 200 mm, and a width of 0.1 to 10 mm.

[0008] Furthermore, the slot units perpendicularly or obliquely intersect with axial direction of the outer conductive body.

[0009] Furthermore, a radial radiation angle of each slot module is between 170 degrees and 360 degrees.

[0010] Furthermore, the slot units of each slot module are spaced apart from and do not communicate with each other, a distance between two adjacent end portions of two adjacent slot units on a unfolded wall of the outer conductor is between 0.5 mm to 50 mm.

[0011] Furthermore, each section of slots includes at least one slot module, the slot modules are arranged along axial direction of the outer conductive body.

[0012] Furthermore, a distance between adjacent slot modules of a same section of slots along the axial direction is 1 mm to 1200 mm.

[0013] Furthermore, directions of adjacent slot modules of the same section of slots are identical to or different from each other.

[0014] Furthermore, the sections of slots are spaced apart from each other by a same distance along axial direction of the outer conductive body, and the distance is between 5 mm to 2000 mm.

[0015] Furthermore, each slot unit is rectangular, L-shaped, U-shaped, triangular, T-shaped, E-shaped, or other varied structure.

[0016] Furthermore, end portion of each slot unit includes a chamfer which has a chamfer radius of 0 mm to 5 mm.

[0017] Compared to the prior art, the wide-angle radiating leaky cable of the present disclosure includes an inner conductive body, an insulating layer, an outer conductive body, and an outer protective casing from the inside to the outside. A plurality of sections of slots are defined on the wall of the outer conductive body, which are equally spaced apart from each other and consist of a plurality of slot modules. Each slot module includes a plurality of slot units which are independent from each other. The wide-angle radiating leaky cable of the present disclosure obtains wide-angle radiating through a distributed leakage mode. By including a plurality of independent slot units in each slot module, the problems of a small slot, a weak intensity of low-frequency radiation, and a narrow radial radiation angle at high frequency resulted from high-frequency signal coverage, can be overcome. The slot unit of a specific design can reduce high-frequency attenuation, so that the leaky cable can be compatible with low-frequency coupling and high-frequency attenuation, has a good signal combining ability, and greatly reduce the cost of indoor signal coverage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] In order to illustrate the embodiments of the present disclosure, descriptions are provided to illustrate

the embodiments.

FIG. 1 is a diagrammatic view of a first embodiment of a wide-angle radiating leaky cable according to present disclosure.

FIG. 2 is a diagrammatic view of a second embodiment of an outer conductive body of FIG. 1.

FIG. 3 is a diagrammatic view of a third embodiment of an outer conductive body of FIG. 1.

FIG. 4 is a diagrammatic view of a fourth embodiment of an outer conductive body of FIG. 1.

[0019] In the drawings, the numbers indicate: 1-inner conductive body, 2-insulating layer, 3-outer conductive body, 7-slot module, 8-slot unit, 4-outer protective casing.

DETAILED DESCRIPTION

[0020] Implementations of the disclosure will now be described, by way of embodiments only, with reference to the drawing. The embodiments shown and described above are only examples. It should be noted that the features in the embodiments of the present disclosure may be combined with each other without conflict.

[0021] The embodiments shown and described above are only examples. The disclosure is illustrative only, and changes may be made in the detail within the principles of the present disclosure, up to and including the full extent established by the broad general meaning of the terms used in the claims. It will, therefore, be appreciated that the embodiments described above may be modified within the scope of the claims.

[0022] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art. The terminologies used in the description of the present disclosure are for describing the embodiments, and are not intended to limit the embodiments of the present disclosure.

[0023] Referring to FIG. 1, a wide-angle radiating leaky cable of the present disclosure, from inner side to outer side, includes:

[0024] An inner conductive body 1. The inner conductive body 1 can be a copper conductor, an aluminum conductor, an electroplated-copper-cladding aluminum conductor, an electroplated-copper-cladding copper conductor, a copper-cladding aluminum conductor, a copper-cladding copper conductor, or a copper-cladding steel conductor. In one embodiment, the inner conductive body 1 can be formed by longitudinally welding a copper strap into a copper tube and embossing spiral wrinkles on the copper tube. In one embodiment, its cross section is circular.

[0025] An insulating layer 2 as a cladding on outer side of the inner conductive body 1. In one embodiment, the insulating layer 2 can be made of foamed polyethylene, polytetrafluoroethylene (PTFE), or fluorinated ethylene propylene (FEP, also known as perfluoroethylene propylene copolymer).

[0026] An outer conductive body 3 defining a plurality of sections of slots on the wall of the outer conductive body 3. The sections of slots are equally spaced apart from each other. Each section of slots is composed of a plurality of slot modules 7. Each slot module 7 includes a plurality of single slot units 8. The slot units 8 are independent from each other, and can be separated from or communicate with each other.

[0027] Referring to FIG. 1, in a first embodiment, the sections of slots are arranged in an array on the wall of the circular outer conductive body 3 along the axial direction of the outer conductive body 3. The slot modules 7 of each section of slots have a same direction, and obliquely intersect with the axial direction of the outer conductive body 3. Each slot module 7 includes two slot units 8 positioned at two cross-sectional plates which are spaced apart and parallel to each other. Each slot unit 8 is rectangular. When the slot modules 7 are projected on the longitudinal cross-sectional plane passing through the center axis, the end portions of the slot units 8 of a same slot module 7, which are adjacent to each other, have a chamfering radius of 0.2 mm, and other end portions, which are far away from each other, have a chamfering radius of 1.5 mm. Each slot unit 8 has a length of 18 mm and a width of 3 mm. The angle between each slot unit 8 and the axial direction is 45 degrees. The minimum distance between two slot units 8 is 3mm. In this embodiment, the leaky cable has a radial radiation angle of 180 degrees, and is compatible with performance at 80 to 3600 MHz.

[0028] Referring to FIG. 2, in a second embodiment, the sections of slots are defined in an array on the wall of the circular outer conductive body 3 along the axial direction of the outer conductive body 3 as shown in the figure. The slot modules 7 of the basics group of slots are arranged resembling the shaped of a Chinese character "eight". The sections of slots at each of the left side and right side include four slot modules 7. Each slot module 7 includes two slot units 8 spaced apart from each other. Each slot unit 8 is rectangular. When the slot modules 7 are projected on the longitudinal cross-sectional plane passing center axis, the end portions of the slot units 8 of a same slot module 7, which are adjacent to each other, have a chamfer radius of 0.1 mm, and other end portions, which are far away from each other, have a chamfer radius of 1 mm. Each slot unit 8 has a length of 15 mm and a width of 2 mm. For each slot module 7 of the sections of slots on the left side, the minimum distance between two adjacent slot units 8 is 2mm, the angle between the upper slot units 8 of the slot module 7 and the axial direction is 55 degrees, the angle between the lower slot units 8 of the slot module 7 and the axial direction is 35 degrees, each two adjacent slot modules 7 has a same distance therebetween along the axis direc-

tion, which is 27mm. For each slot module 7 of the section of slots on the right side, the minimum distance between two adjacent slot units 8 is 4 mm, the angle between the upper slot unit 8 of the slot module 7 and the axial direction is 110 degrees, the angle between the lower slot unit 8 of the slot module 7 and the axial direction is 125 degrees, each two adjacent slot modules 7 has a same distance therebetween along the axis direction, which is 27mm. The distance between one slot module 7 adjacent to the right side of the section of slots and one slot module 7 adjacent to the left side of the section of slots along the axial direction is 50 mm. In this embodiment, the leaky cable has a radial radiation angle of 200 degrees, and is compatible with performance at 80 to 3800 MHz.

[0029] Referring to FIG. 3, in a third embodiment, the sections of slots are defined in an array at the wall of the circular outer conductive body 3 along the axial direction of the outer conductive body 3 as shown in the figure. The slot modules 7 of the sections of slots are arranged resembling the shaped of a Chinese character "eight". Each section of slots at each side includes three slot modules 7. Each slot module 7 includes three slot units 8 positioned on a same cross-sectional plane. Each slot unit 8 is rectangular. When the slot modules 7 are projected on the longitudinal cross-sectional plane passing through the center axis, the end portions of the slot units 8 of a same slot module 7 have a chamfer radius of 0 mm. The center slot unit 8 of each slot module 7 has a length of 8 mm. Both the upper slot unit 8 and the lower slot unit 8 of each slot module 7 have a length of 5 mm and a width of 2 mm. For the three slot module 7 of the section of slots on the left side, the two adjacent slot units 8 has a same minimum distance, which is 2mm, the angle between the slot units 8 and the axial direction is 40 degrees, each two adjacent slot modules 7 has a same distance therebetween along the axis direction, which is 20mm. For the three slot module 7 of the sections of slots on the right side, two adjacent slot units 8 has a same minimum distance, which is 2 mm, the angle between the slot units 8 and the axial direction is 140 degrees, each two adjacent slot modules 7 has a same distance therebetween along the axis direction, which is 20 mm. The distance between one slot module 7 adjacent to the right side of the section of slots and one slot module 7 adjacent to the left side of the section of slots along the axial direction is 45 mm. In this embodiment, the leaky cable has a radial radiation angle of 220 degrees, and is compatible with performance at 80 to 6000 MHz.

[0030] Referring to FIG. 4, in a fourth embodiment, the sections of slots are arranged in an array on the unfolded wall of the circular outer conductive body 3. The slot modules 7 of each section of slots has a direction perpendicular to the axial direction of the outer conductive body 3. Each slot module 7 includes two slot units 8 positioned on a same cross-sectional plane. Each slot unit 8 is rectangular. When the slot modules 7 are projected on the longitudinal cross-sectional plane passing through the center axis, the end portions of each slot unit have a chamfer radius of 0.3 mm. Each slot unit 8 has a length of 8 mm and a width of 3 mm. Each two adjacent slot units 8 has a same minimum distance, which is 1 mm. The distances between each two adjacent slot modules 7, from left to right along the axial direction, are 28 mm, 11 mm, 19 mm, 11 mm, 19 mm, 11 mm, and 28 m. In this embodiment, the leaky cable has a radial radiation angle of 185 degrees, and is compatible with performance at 80 to 6000 MHz.

[0031] In other embodiments, the number of the slot module(s) 7 of each section of slots may be one or more, and is not limited to the embodiment. In other embodiments, each slot unit 8 has a length of 1 to 200 mm, and a width of 0.1 to 10 mm, which are not limited to the embodiment. The minimum distance between each two adjacent slit units 8 on the unfolded wall of the outer conductive body is 0.5 to 50 mm, and is not limited to the embodiment. Each slot unit 8 may be rectangular, L-shaped, U-shaped, triangular, T-shaped, E-shaped, or other varied structure. In other embodiment, the angle of each slot unit 8 obliquely intersect with the outer conductive body 3 is not limited to the embodiment. In other embodiments, the directions of the slot modules 7 of the same section of slots, and the distances therebetween, can be partially identical, totally identical, or completely different from each other, and are not limited to the embodiment. In other embodiments, the distance between adjacent slot modules 7 of the same section of slots along the axial direction is 1 mm to 1200 mm, and is not limited to the embodiment. In other embodiments, the slot modules 7 of the same section of slots can have a same direction, different directions, or can also intersect on different planes. In other embodiments, the directions of the slot units 8 of the same slot module 7 can be partially the identical, totally identical, or completely different from each other. The micro angular offset caused by machining error belongs to a normal system error, which is within the principles of the present disclosure.

[0032] In the embodiment, the sections of slots shown in FIGS. 1 to 4 are defined as a basic unit of the slots defined on the outer conductive body. In practical use, a plurality of such basic units are arranged on the outer conductive body to achieve functional requirements. In the embodiment, the distance between the adjacent basic units may be 210 mm, 262 mm, etc. It can be understood that the distance may be varied from 5 mm to 2000 mm, depending on the number of the slot modules 7 and the slot units 8 included therein. To satisfy the requirements of the performance design, the variation is not limited to the embodiment. Based on the combination design of the slot modules 7 and the slot units 8, the radial radiation angle can be increased between 170 degrees and 360 degrees, and is not limited to the embodiment.

[0033] An outer protective casing 4 coated on the outer layer of the outer conductive body 3. The outer protective casing 4 is made of polyethylene or flame retardant polyolefin. In the embodiment, its cross section may be circular, semi-circular, rectangular, fan-shaped, or other

varied structure thereof.

[0034] In summary, the wide-angle radiating leaky cable of the present disclosure obtains wide-angle radiating through a distributed leakage mode. The wide-angle radiating leaky cable has a radial radiation angle which reaches 170 degrees or more, and is compatible with low frequency coupling and high frequency attenuation. Thus, the wide-angle radiating leaky cable is suitable for long-distance transmission and signal coverage of microwave signals, has a good signal combination capability, and can greatly reduce the cost of indoor signal coverage.

[0035] The embodiments shown and described above are only examples. The disclosure is illustrative only, and changes may be made in the detail within the principles of the present disclosure, up to and including the full extent established by the broad general meaning of the terms used in the claims. It will, therefore, be appreciated that the embodiments described above may be modified within the scope of the claims.

Claims

1. A wide-angle radiating leaky cable, from inner side to outer side, comprising an inner conductive body (1), an insulating layer (2), an outer conductive body (3), and an outer protective casing (4), wherein, a plurality of sections of slots are defined on wall of the outer conductive body (3), the sections of slots are equally spaced apart from each other, each section of slots is composed of a plurality of slot modules (7), each slot module (7) comprises a plurality of slot units (8) independent from each other.

2. The wide-angle radiating leaky cable of claim 1, wherein each slot unit (8) has a length of 1 to 200 mm, and a width of 0.1 to 10 mm.

3. The wide-angle radiating leaky cable of claim 1, wherein the slot units (8) perpendicularly or obliquely intersect with axial direction of the outer conductive body (3).

4. The wide-angle radiating leaky cable of claim 1, wherein a radial radiation angle of each slot module (7) is between 170 degrees and 360 degrees.

5. The wide-angle radiating leaky cable of claim 1, wherein the slot units (8) of each slot module (7) are spaced apart from and do not communicate with each other, a distance between two adjacent end portions of two adjacent slot units (8) on a unfolded wall of the outer conductor (3) is between 0.5 mm to 50 mm.

6. The wide-angle radiating leaky cable of claim 1, wherein each section of slots includes at least one slot module (7), the slot modules (7) are arranged along axial direction of the outer conductive body (3).

7. The wide-angle radiating leaky cable of claim 6, wherein a distance between adjacent slot modules (7) of a same section of slots along the axial direction is 1 mm to 1200 mm.

8. The wide-angle radiating leaky cable of claim 6, wherein directions of adjacent slot modules (7) of the same section of slots are identical to or different from each other.

9. The wide-angle radiating leaky cable of claim 1, wherein the sections of slots are spaced apart from each other by a same distance along axial direction of the outer conductive body (3), and the distance is between 5 mm to 2000 mm.

10. The wide-angle radiating leaky cable of claim 1, wherein each slot unit (8) is rectangular, L-shaped, U-shaped, triangular, T-shaped, E-shaped, or other varied structure.

11. The wide-angle radiating leaky cable of claim 1, wherein end portion of each slot unit (8) includes a chamfer which has a chamfer radius of 0 mm to 5 mm.

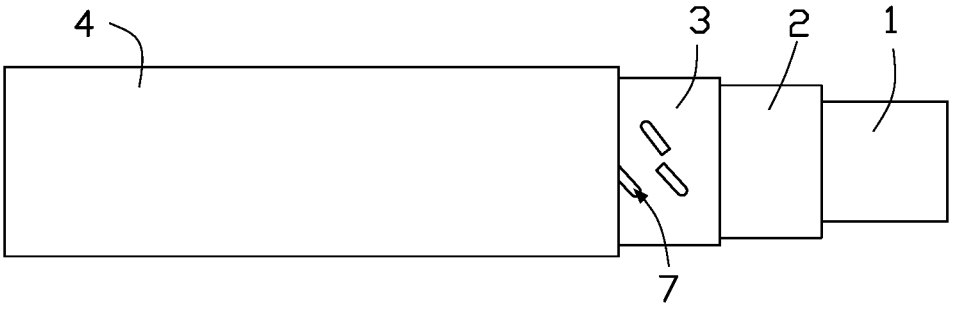

FIG. 1

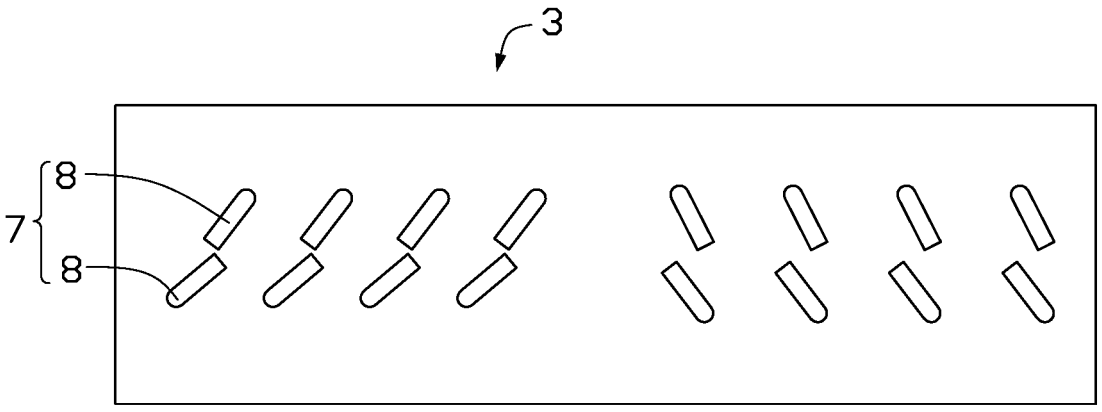

FIG. 2

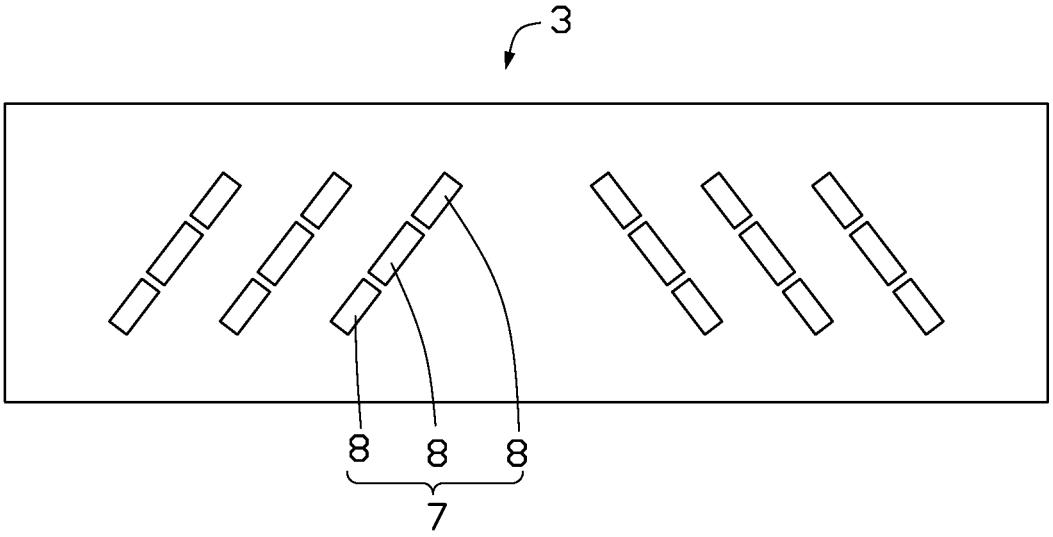

FIG. 3

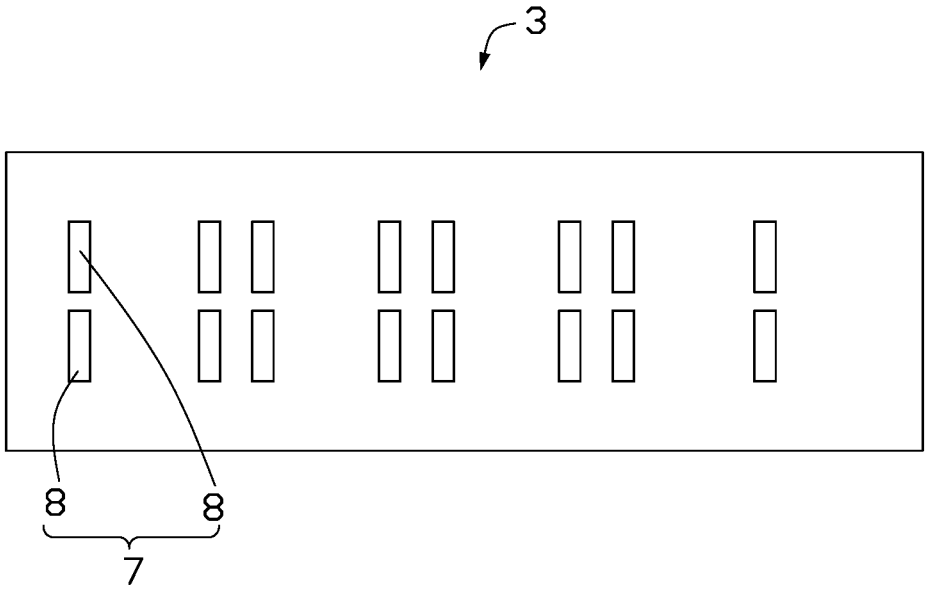

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/117275

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 13/20(2006.01)i; H01P 3/06(2006.01)i

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)

H01Q13/-, H01P3/-

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)

CNPAT, CNKI, EPODOC, WPI: 广, 角度, 范围, 辐射, 漏, 缆, 外导体, 槽, 缝, 阵列, 序列, wide, angle, range, outer w conductor, groove, slot, gap, array, sequence, cable

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 108390155 A (ZHONGTIAN RF CABLE CO., LTD.) 10 August 2018 (2018-08-10) description, paragraphs [0004]-[0025], and figures 1-3	1-11
X	CN 208028215 U (ZHONGTIAN RF CABLE CO., LTD.) 30 October 2018 (2018-10-30) description, paragraphs [0004]-[0030], and figures 1-3	1-11
A	CN 102013540 A (BEIJING JIAOTONG UNIVERSITY) 13 April 2011 (2011-04-13) entire document	1-11
A	CN 102290625 A (ZHONGTIAN HITACHI RF CABLE CO., LTD.) 21 December 2011 (2011-12-21) entire document	1-11
A	JP 2018088586 A (HITACHI METALS LTD.) 07 June 2018 (2018-06-07) entire document	1-11
A	JP H10145136 A (HITACHI CABLE LTD.) 29 May 1998 (1998-05-29) entire document	1-11

☐ 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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"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
12 July 2019	**21 August 2019**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088** **China**	Authorized officer
Facsimile No. **(86-10)62019451**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/117275

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 108390155 A	10 August 2018	None	
CN 208028215 U	30 October 2018	None	
CN 102013540 A	13 April 2011	CN 102013540 B	23 January 2013
CN 102290625 A	21 December 2011	None	
JP 2018088586 A	07 June 2018	None	
JP H10145136 A	29 May 1998	None	

Form PCT/ISA/210 (patent family annex) (January 2015)