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THE MICROWAVE JOURNAL, December 1970, pages 49-54, C. KILGUS: "Resonant Quadrifilar Helix Design"
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Description

Technical field

The invention relates to a transmitter-receiver system, which as a link in a satellite will receive and transmit signals in the microwave range between one earth station and another earth station. More specifically the invention relates to a transmitter-receiver system in which a new type of omnidirectional circularly polarised aerial or antenna is included.

Background art

It is already known to use a so-called quadrifilar helix aerial, i. e. an omnidirectional aerial, mainly consisting of four longitudinal wires, which constitue the antenna radiation element and which are twisted round the longitudinal axis of the aerial, as described in « The Microwave Journal » December, 1970, pp 49-53. Such an omnidirectional antenna has a relatively large lobe width ($0 > 90°$), making it suitable for satellite communication.

Disclosure of invention

In certain cases, however, extremely high coverage ($O \geqslant 120°$) is required from the aerial, so that the satelite may be reached by signals in its orbit, relatively independently of its own orientation to the earth's surface. At the same time there is a desire for the aerial to have high cross polarisation, as well as large bandwidth (200 MHz at 2 GHz), i. e. it must be able to link radio signals that are both right (RHC) and left polarised (LHC) with retained large coverage (O is still large). Figure 1 on the accompanying drawing illustrates a typical aerial diagram for the known quadrifilar helix aerial (field strength FS as a function of the angle O from the antenna axis). It will be seen from the diagram that the antenna has good coverage for right-hand polarised interference signal, almost up to 120° width in this case, but that a left-hand polarised interference signal also occurs at lobe angles around 90°, since this signal does not contribute further to the lobe width.

If the earth station is capable of receiveing (or transmitting) both ledt and right polarised signals at the same time, high cross polarisation could be useful. Most earth stations can receive both types.

According to the proposed invention, the antenna in the transmitter-receiver system it is included in, is formed as an octofilar crossed helix antenna, resulting in that there is obtained the desired high cross polarisation, apart from the normal polarisation. This means that the coverage increases in relation to the quadrifilar helix antenna, since the octofilar antenna has a lobe diagram for left polarised signals (LHC) even when $O > 120°$. There is thus obtained a system with a practically completely omnidirectional antenna with respect to radiated power.

The proposed transmitter-receiver system is implemented as defined in the characterising portion of claim 1.

Brief description of drawings

The invention will now be described in detail, with reference to the accompanying drawing, where Figure 1 is a lobe diagram for a known quadrifilar antenna.

Figure 2 is a block diagram of the transmitter-receiver system in accordance with the invention.

Figure 3 schematically illustrates the construction of the antenna included in the system in Figure 2.

Figure 4 illustrates a conventional adaptor unit included in the system in Figure 1.

Figure 5, in correspondence with Figure 1, is a lobe diagram for antennas included in the system in Figure 2.

Best modes for carrying out the invention

A first and a second transmitter-receiver unit are respectively denoted by SM1 and SM2 in the block diagram according to Figure 2. These units are conventional and are connected in a suitable way to a directional switch RK (3dB hybrid). Both outputs of the switch are connected to an adaptor unit BL, a so-called « balun », which diverts the signals sent from the switch to four outputs in this case, from which signals with different phase shifts 0°, 90°, 180° and 270° are obtained. The balun BL, shown in detail in Figure 4, further serves as mechanical support for the antenna unit AN, which is shown in more detail in Figure 3. This unit is an octofilar crossed helix antenna, which has the property of transmitting and receiving cross-polarised signals, such that it acts omnidirectionally within a given angle O. The fact that the antenna unit ARI has high cross polarisation enables both right and left polarised signals to be processed by the system, providing that both types of signals can be processed simultaneously or individually by the earth station. The transmitter-receiver unit SMI may be intended for the right-hand polarised (RHC) signals as chief polarisation, while the unit SM2 is then intended for the left-hand polarised (LHC) signals as chief polarisation. The directional switch RK equally divides the power from a transmitter-receiver unit on its two outputs, mutually phase-shifted 90°. If, for example, the unit SMI is connected to the port in the directional switch RK that gives right-hand polarisation (RHC) as chief polarisation (copolarisation), the radiation diagram for the antenna AN will have the appearance depicted in Figure 5. The radiation diagram from the unit SM2, which is then connected to the other input of the switch RK, will have the appearance as in Figure 5, except that the denotations RHC and

LHC change places. Which SM unit is used depends on the application, but most usual is that SM2 replaces SM1 if the latter fails, i. e. a redundant system. It is, however, quite possible to use both transmitter-receiver units simultaneously.

In previously known systems, which use a quadrifilar helix as antenna unit, the use of a three-port electromagnetic switch is necessary, the switch being connected between both units SM1 and SM2 and the switch RK for switching in the unit to be utilised. In this case only one polarisation is utilised, right or left, and chief polarisation will remain the same irrespective of what SM unit is used (c.f. Figure 1). This switch is not needed in the inventive system, since both left and right polarised signals have equivalent lobe coverage (c.f. Figure 5). In one case the right-hand circularly polarised field is the chief polarisation, and in the other, the left-hand circularly polarised field. That the switch is despensed with, considerably increases the system reliability.

Figure 3 illustrates the appearance of the antenna unit AN in more detail. As mentioned, this is an octofilar crossed helix antenna, in contradistinction to previously known systems, in which a quadrifilar helix was utilised. It may be said that the antenna is in principle built up from two crossing arms with a given mutual spacing. One pair of crossed arms a_1, a_3 and a^2, a_4 define an upper antenna plane with end points k_1-k_4, and the other pair a_5-a_7 and a_6, a_8 defines a lower antenna plane with end points k_5-k_8. The arms a_1-a_4 in the upper plane and arms a_5-a_8 in the lower are situated relative each other such that respective end points k_1-k_4 and k_5-k_8 are directly opposing, i. e. end point k_1 is opposite k_5, k_2 is opposite k_6 etc. Two wires run from each point in the upper plane to the end points in the lower plane, that are situated nearest before and nearest after the end point, opposite the first-mentioned end point. For example, the wires t_{16} and t_{18} run from the end point k_1 to the end points k_8 and k_8 in the lower plane, the wires e_{25} and e_{27} run correspondingly from the end point k_2 to the points k_5 and k_7, the wires t_{36} and t_{38} from the end point k_3 to end points k_6 and k_8, and the wires t_{45}, t_{47} run from the end point k_4 to the points k_5 and k_7. The octofilar helix antenna illustrated in Figure 3 may be said to consist of two quadrifilar helix antenna, of which one (antenna elements : wires t_{18}, t_{25}, t_{36}, t_{47}) can receive left polarised, and the other (antenna elements : wire t_{16}, t_{27}, t_{38}, t_{45}) can receive right polarised signals. The antenna radiation element thus comprises conductive wires (usually of copper), which depart in pairs from each of four end points k_1, k_2, k_3, k_4 in a plane, the wires being bent and twisted with uniform pitch a quarter of a turn forwards or backwards, as respectively seen from each of the end points in the upper and lower planes of the antenna.

Figure 5 is the radiation diagram for the octofilar helix antenna according to Figure 3 with right-hand polarisation. It will be seen from the diagram that the antenna lobe angle for both left and right polarised signals is increased, particularly for left polarised signals (cross polarised), compared with the diagram of Figure 1. When the antenna field strength for right-hand polarised signals (RHC) falls for lobe angles O between 90° and 180°, the radiation field strength of left-hand polarised (LHC) signals will increase instead, and first decline substantially for angles close to 180°. There is thus obtained good lobe coverage, at least up to O = 150°. The location of the radiation lobes (field strength) in the O direction, may be changed for a given microfrequency by changing the radial distance r and/or the height h, the pitch angle O in Figure 3.

Figure 4 illustrates in detail how the octofilar helix antenna is arranged at its feed end (the upper antenna plane) as a balun. The four coaxial conductors b1-b4 of the balun have their respective screens connected to a common earth or ground plane JP. The centre conductors are connected to the four arms a1, a4, of the helix antenna, these being split up in pairs and each pair bridged by a bridge b13 and b24, respectively. Feeding the microwave signals to the four arms a1-a4 is thus obtained, the arms being mutually relatively displaced by 90°. The antenna elements, i. e. the wires t8, t16 etc, run from the respective end points k1-k4 of the arms a1-a4, as illustrated in Figure 3. The end points k5, k6, k7 and k8 may be attached by the arms a5-a6 to the balun ground plane JP in a suitable way, or by an unillustrated screen to the balun, e. g. as illustrated for the quadrifilar helix antenna, discussed in the above-mentioned article from « The Microwave Journal », see Figure 1.

The helix antenna radiation elements, i. e. the wires t6, t18 etc, may each have a length equal to a multiple of λ/2, so that they form a resonant antenna, which is the preferred embodiment. In some applications, however, it is advantageous to form the antenna as non-resonant.

The antenna may be manufactured according to known technique. It is very light with wide bandwidth, compared with a slitted wave conductor antenna. The inventive system is primarily intended as a link antenna in satellite projects concerned with so-called relemetry and rele command links.

Claims

1. A transmitter-receiver system as a link in a satellite containing an omnidirectional circularly polarised aerial or antenna (AN), an adaptor unit (BL) for feeding the antenna elements with signals of suitable phase (0°, 90°, 180°, 270°), a directional switch device (RK) for passing mutually phase-shifted signals (0°, 90°) to the adaptor device (BL), and a transmitter-receiver part (SM1, SM2) for processing the signals received or transmitted by the antenna (AN), characterized in that the antenna (AN) is an octofilar helix antenna having four forwards twisted (t_{16}, t_{27}, t_{38}, t_{45}) and four backwards twisted (t_{18}, t_{25}, t_{36}, t_{47})

antenna elements where the forwards and backwards twisted elements (t_{16}-t_{18} ; t_{27}-t_{25} ; t_{38}-t_{36} ; t_{45}-t_{47}) are pairwise fed from a common point (k_1, k_2, k_3, k_4 respectively) for obtaining good lobe coverage with both right (RHC) and left polarised (LHC) signals.

2. System as claimed in claim 1, characterized in that the antenna (AN) comprises two pairs of crossed arms (a_1-a_4 and a_5-a_8) at given mutual spacing (d), and located so that the end points of the arms of each pair are placed substantially opposite each other, the antenna element comprising wires (t_{16}-t_{47}) arranged such that from the end points of one arm pair (a_1-a_4) a first wire (for example t_{16}) runs from an end point (for example k_1) to the end point (for example k_6) of the other arm pair (a5-a8), the end point (k6), being situated opposite the nearest preceding end point (k_2), and a second wire (for example t_{18}) runs from the first-mentioned end point (k_1) to the end point (k_8) of the other arm pair (a_5-a_8), such that this end point is nearest following after the end point (k_1).

Patentansprüche

1. Sender-Empfänger-System als Übertragungsglied in einem Satellit mit einem rundstrahlenden zirkularpolarisierten Strahler oder Antenne (AN), einer Adaptereinheit (BL) zur Speisung der Antennenelemente mit Signalen geeigneter Phase (0°, 90°, 180°, 270°), einer gerichteten Schaltvorrichtung (RK) zum Weiterleiten von zueinander phasenverschobenen Signalen (0°, 90°) zu der Adaptereinheit (BL) und einem Sender-Empfänger-Teil (SM1, SM2) für die Verarbeitung der über die Antenne (AN) empfangenen oder abgestrahlten Signale, dadurch gekennzeichnet, daß die Antenne (AN) eine octofilare Helixantenne ist, die vier vorwärts verdrehte (t_{16}, t_{27}, t_{38}, t_{45}) und vier rückwärts verdrehte (t_{18}, t_{25}, t_{36}, t_{47}) Antennenelemente aufweist, wobei die vorwärts und rückwärts verdrehten Elemente (t_{16}-t_{18} ; t_{27}-t_{25} ; t_{38}-t_{36} ; t_{45}-t_{47}) paarweise von einem gemeinsamen Punkt (k_1, k_2, k_3, k_4) aus gespeist werden, um eine gute Strahlungskeulenbedeckung mit sowohl rechts (RHC) als auch links (LHC) polarisierten Signalen zu erzielen.

2. System nach Anspruch 1, dadurch gekennzeichnet, daß die Antenne (AN) zwei Paare aus gekreuzten Armen (a_1-a_4 und a_5-a_8) in einem vorgegebenen Abstand (d) zueinander aufweist, und so angeordnet ist, daß die Endpunkte der Arme eines jeden Paares im wesentlichen einander gegenüberliegend plaziert sind, wobei die Antennenelemente Drähte (t_{16}-t_{47}) umfassen, die so angeordnet sind, daß von den Endpunkten eines Armpaares (a_1-a_4) ein erster Draht (z. B. t_{16}) von einem Endpunkt (z. B. k_1) zu dem Endpunkt (z. B. k_6) des anderen Armpaares (a_5-a_8) verläuft, wobei der Endpunkt (k_6) dem nächsten vorangehenden Endpunkt (k_2) gegenüberliegt und ein zweiter Draht (z. B. t_{18}) von dem zuerst genannten Endpunkt (k_1) zu dem Endpunkt (k_8) des anderen Armpaares (a_5-a_8) verläuft, so daß dieser Endpunkt der nächstfolgende nach dem Endpunkt (k_1) ist.

Revendications

1. Un système émetteur-récepteur remplissant une fonction de liaison dans un satellite et comportant une antenne omnidirectionnelle à polarisation circulaire (AN), un adaptateur (BL) destiné à appliquer aux éléments d'antenne des signaux de phase appropriée (0°, 90°, 180°, 270°), un dispositif de commutation directionnel (RK) destiné à transmettre à l'adapteur (BL) des signaux mutuellement déphasés (0°, 90°), et un dispositif émetteur-récepteur (SM1, SM2) destiné à traiter les signaux reçus ou émis par l'antenne (AN), caractérisé en ce que l'antenne (AN) est une antenne à hélice à huit fils comportant quatre éléments d'antenne vrillés en sens direct (t_{16}, t_{27}, t_{38}, t_{45}) et quatre éléments d'antenne vrillés en sens inverse (t_{18}, t_{25}, t_{36}, t_{47}), les éléments vrillés en sens direct et en sens inverse (t_{16}-t_{18} ; t_{27}-t_{25} ; t_{38}-t_{36} ; t_{45}-t_{47}) étant alimentés par paires à partir d'un point commun (respectivement k_1, k_2, k_3, k_4), pour obtenir une bonne couverture de lobe à la fois avec des signaux en polarisation à droite (RHC) et des signaux en polarisation à gauche (LHC).

2. Système selon la revendication 1, caractérisé en ce que l'antenne (AN) comprend deux paires de bras croisés (a_1-a_4 et a_5-a_8), qui ont un écartement mutuel donné (h), et qui sont disposés de façon que les points d'extrémités des bras de chaque paire soient placés pratiquement face à face, les éléments d'antenne comprenant des fils (t_{16}-t_{47}) disposés de façon qu'en partant des points d'extrémités d'une paire de bras (a_1-a_4), un premier fil (par exemple t_{16}) s'étende d'un point d'extrémité (par exemple k_1) vers le point d'extrémité (par exemple k_6) de l'autre paire de bras (a_5-a_8), ce point d'extrémité (k_6) étant situé face au point d'extrémité précédent le plus proche (k_2), et un second fil (par exemple t_{18}) s'étende du point d'extrémité mentionné en premier (k_1) jusqu'au point d'extrémité (k_8) de l'autre paire de bras (a_5-a_8) qui est opposé au point d'extrémité le plus proche qui suit le point d'extrémité mentionné en premier (k_1).

Fig. 1

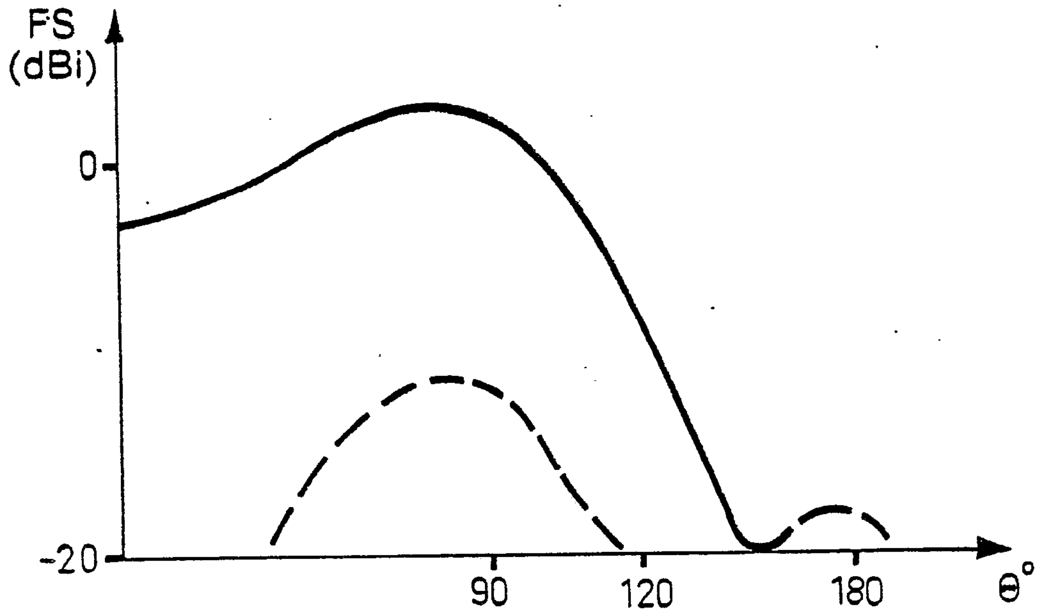
FS
(dBi)
0
-20
90
120
180
θ°

Fig. 2

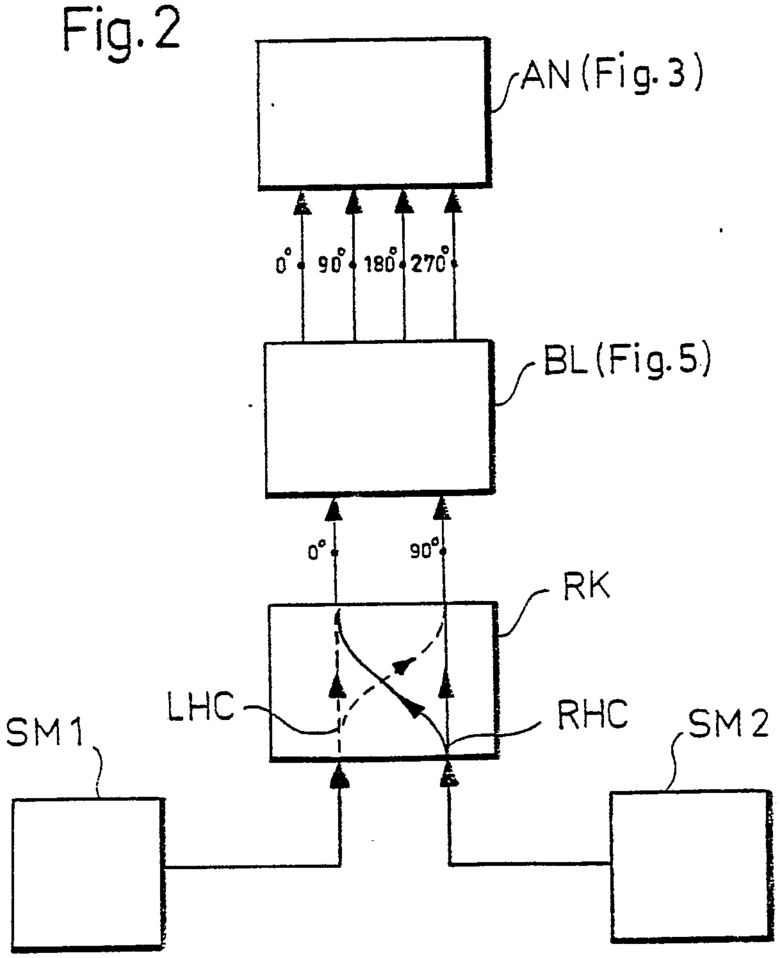
AN (Fig. 3)
0°
90°
180°
270°
BL (Fig. 5)
0°
90°
RK
LHC
RHC
SM 1
SM 2

Fig. 3

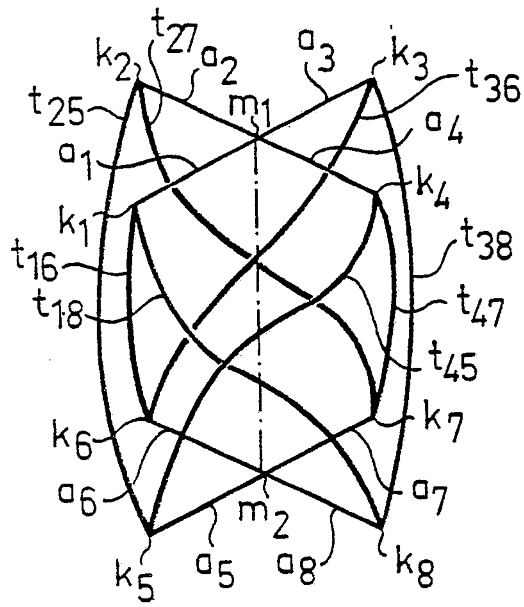
k2
t27
a2
a3
k3
t36
t25
m1
a4
a1
k4
k1
t16
t38
t18
t47
t45
k6
k7
a6
a7
m2
k5
a5
a8
k8

Fig. 4

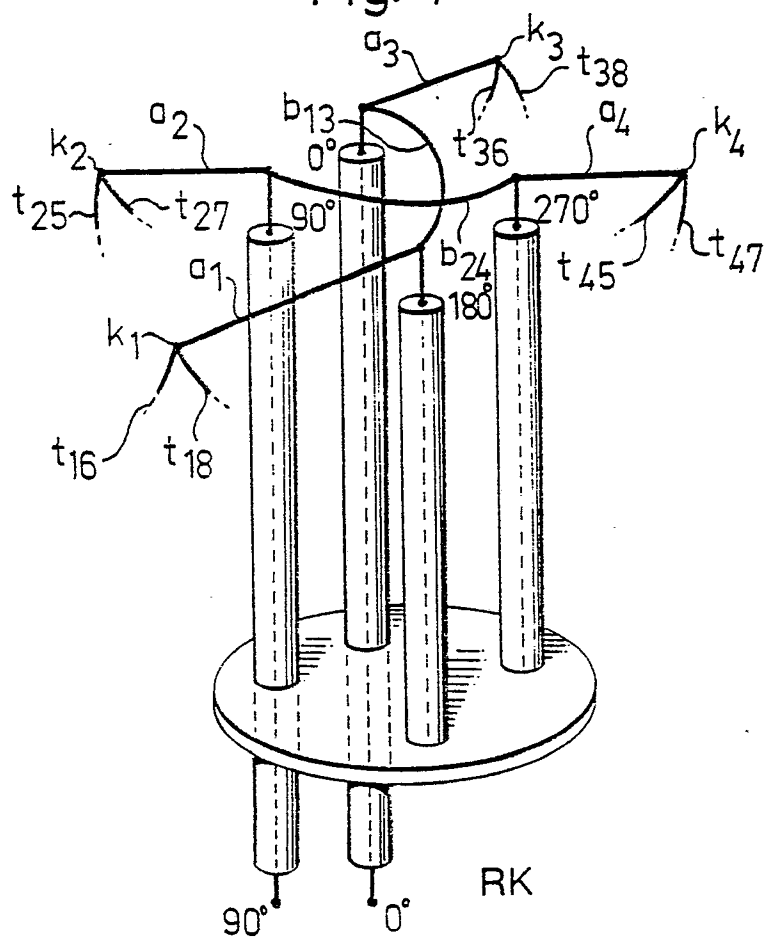
a3
k3
t38
b13
t36
a4
k4
a2
0°
k2
t25
t27
90°
270°
b24
t45
t47
a1
180°
k1
t16
t18
RK
90°
0°

Fig. 5