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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04B 7/06

A1

(11) International Publication Number: WO 97/42718

(43) International Publication Date: 13 November 1997 (13.11.97)

(21) International Application Number: PCT/US97/07307

(22) International Filing Date: 30 April 1997 (30.04.97)

(30) Priority Data:
08/642,486 3 May 1996 (03.05.96) US

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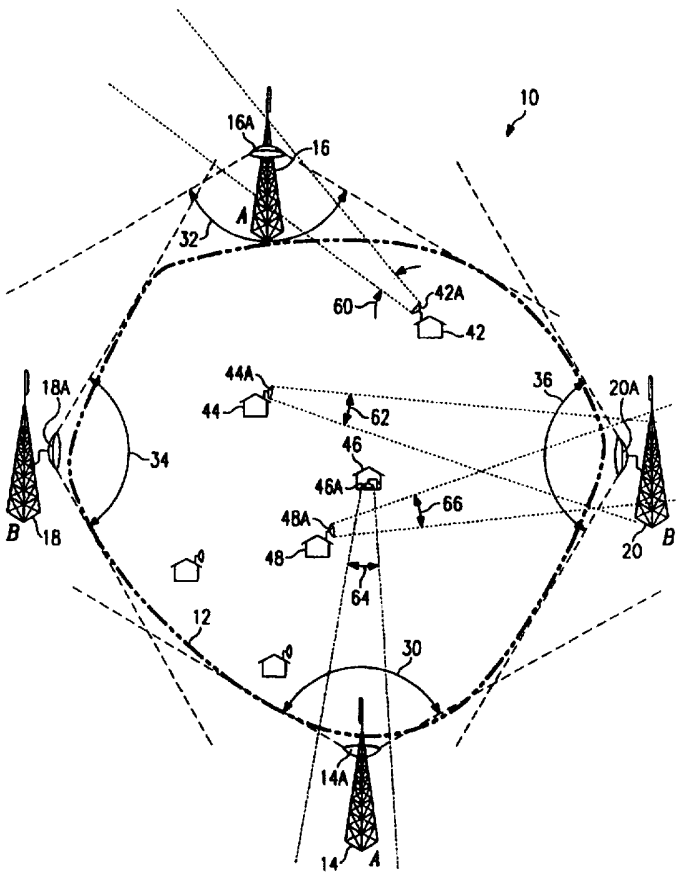
(81) Designated States: AU, BR, CA, CN, IL, JP, KR, MX, NZ, Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: BROADCAST SYSTEM WITH BAND REUSE

(57) Abstract

A broadcast system (10) operates with a plurality of transmit sites (14, 16, 18, 20), each provides a line-of-sight transmission pattern (30, 32, 34, 36) to a single service area (12). A plurality of receive sites (42, 44, 46, 48) are located in the service area (12) and each is provided with a narrow beamwidth directional receive antenna (42A, 44A, 46A, 48A) which is focused toward only one of the transmit sites (14, 16, 18, 20). The transmit sites are positioned sufficiently distant from each other such than only one transmit site is within the main lobe beam pattern (62, 64, 66) of a receive antenna within the service area (12). The transmit sites provide a plurality of multiuse microwave signals (A, B) on a common band to a single service area so that there is reuse of the available spectrum. The reuse of the spectrum can be applied to each of a plurality of band that are available in a given service area.



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BROADCAST SYSTEM WITH BAND REUSE

TECHNICAL FIELD OF THE INVENTION

The present invention pertains in general to broadcast systems, such as television broadcasting, and in particular to a configuration for a broadcasting system in which a single band is used concurrently for transmission of different multiuse microwave signals in a single service area from multiple transmission sites.

BACKGROUND OF THE INVENTION

The number of stations that can broadcast television signals in any one area is limited by the available spectrum. The demand for spectrum allocations far exceeds the spectrum which is available. Current government policy is to auction spectrum to the highest bidder, and this procedure has made spectrum allocation even more valuable.

There must be a substantial geographical distance between two transmitters operating on the same band to prevent signal interference. This distance must be sufficient so that the two carrier signals are not received at the same time by a single receive antenna.

The present invention is directed to a broadcasting system configuration which permits multiple multiuse microwave signals to be carried on the same band in the same geographic area. This allows for spectrum reuse since a single band can be used by multiple parties in a single geographic area.

SUMMARY OF THE INVENTION

A selected embodiment of the present invention is a broadcast system for providing multiple multiuse microwave signals concurrently on a single band to a unitary service area. It includes one or more first multiuse microwave signal transmit sites, each of which has a transmit antenna for line-of-sight broadcasting on said band to the service area. The system further includes one or more second multiuse microwave signal transmit sites, each of which has a transmit antenna for line-of-sight broadcasting on the same band to the same service area. The first multiuse microwave signal is different from the second multiuse microwave signal. A plurality of receive sites are present within the service area. Each receive site has a directional antenna which has a beamwidth that is less than the beamwidth of the transmit antennas. A first set of the receive sites has each directional antenna thereof focused toward one of the transmit antennas for the first multiuse microwave signal transmit sites. A second set of the receive sites has each of the directional antennas thereof focused toward one of the transmit antennas for the second multiuse microwave signal transmit sites. The first and second multiuse microwave signal sites are sufficiently distant from each other such that only one of the multiuse microwave signal transmit sites is within the beam of any one of the receive site directional antennas.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is an illustration of a service area which receives a first multiuse microwave signal from a first pair of transmit sites and a second multiuse microwave signal from a second pair of transmit sites but with all transmit sites transmitting on a common band, and

Figure 2 is an illustration of such a system as shown in Figure 1 but including multiple multiuse microwave signals being transmitted on each of a plurality of bands to illustrate multiple reuse of broadcast bands.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figure 1, there is illustrated a broadcast system 10 in accordance with the present invention. The present invention, in addition to video, may also be used to broadcast other microwave services such as facsimile (fax), data and audio. Broadcast system 10 provides multiple multiuse microwave signals to a service area 12, generally indicated by the dashed line. The service area can have almost any shape. A first multiuse microwave signal A is provided by the transmit sites 14 and 16. A second multiuse microwave signal B is provided by the transmit sites 18 and 20. The transmit sites 14, 16, 18 and 20 have respective transmit antennas 14A, 16A, 18A and 20A. The transmit sites are positioned along the periphery of the service area 12.

Each of the transmit sites is provided with a transmit antenna which transmits a signal on a common frequency band. Thus, all four transmit sites operate on the same band; however, the sites 14 and 16 transmit one multiuse microwave signal (A) and the sites 18 and 20 transmit a different multiuse microwave signal (B).

In an application such as subscription television which is distributed by line-of-sight transmission, a broadcast band can be a one gHz segment of spectrum, for example, from 29 gHz to 30 gHz. A second band can be, for example, from 30 gHz to 31 gHz. Each band carries a multiuse microwave signal which typically comprises a plurality of channels, each which may include a group of video channels. If each channel is allocated a bandwidth of 20 MHz, then 50 channels can be carried in one band. Each channel need not have the same bandwidth. For example, an audio channel requires much less bandwidth than a video channel. Further, a band may have only one channel.

Transmit site 14 produces a transmit beam pattern 30 which, for the illustrated embodiments, has an angle of less than 180°, but substantially encompasses the service area 12. However, any beamwidth can be used which is needed to cover the service area. A wide beamwidth may be required for a service area which has an unusual shape or mountain topography. The transmit site 16 antenna produces a beam pattern 32 which likewise substantially encompasses the service area 12. In a similar manner, the transmit site 18 has

a beam pattern 34 and the transmit site 20 has a beam pattern 36. The sites 14, 16, 18 and 20 are located on the outside of service area 12 and along the periphery thereof.

All of the transmit sites have transmitters which operate at frequencies of one gHz or above. In preferred embodiments, the transmitters operate above 20 gHz.

The service area 12 includes a plurality of receive sites 42, 44, 46 and 48. These are generally schools or consumer locations such as residences or businesses. Each receive site is provided with a directional receive antenna as indicated in Figure 1. Each receive site has a small antenna, such as a parabolic dish. For the receive sites 42-48, these are directional receive antennas 42A, 44A, 46A and 48A. The preferred embodiments of the receive antennas, together with appropriate receivers and down converters, are manufactured by GHz Equipment Company, Inc., located at Tempe, Arizona. Such equipment is available for frequency bands above 20 gHz. The beamwidth of a receive site antenna is dependent upon the size of the antenna and the operating frequency. Transmitters and the associated equipment needed for broadcasting at these frequency bands are also available from GHz Equipment Company, Inc.

The receive sites 42, 44, 46 and 48 have respective receive antenna main lobe beamwidth patterns 60, 62, 64 and 66. These patterns preferably have a beamwidth with performance characteristics such that the differential between the main lobe and its side lobes is at least -30 dBi. The preferred main lobe beamwidth is in the range of 1.3° to 5°.

In the operation of the present invention, further referring to Figure 1, all four transmit sites operate on the same band, for example, 29-30 gHz. The sites 14 and 16 transmit a different multiuse microwave signal from that of the sites 18 and 20. Each receive site has its respective directional receive antenna focused toward one, and only one, transmit site. The transmit sites are positioned at such a distance from each other such that each receive site within the service area 12 can have only one transmit site within the main lobe beam pattern of its directional receive antenna at any one time. The receive antennas are fixed in place once a particular transmit site is selected. A particular receive site can

receive signals from both the A and B multiuse microwave signal transmit sites at one time if it has multiple receive antennas.

As shown in Figure 1, the receive site 42 has its narrow beam receive antenna focused toward the transmit site 16. Although receive site 42 is within the beam pattern of all the other three transmit sites 14, 18 and 20, it receives only the multiuse microwave signal from transmit site 16.

The receive site 44 antenna is focused toward the transmit site 20 and receives only the signal from that site. In a similar manner, the receive site 46 antenna is focused only toward transmit site 14 and receive site 48 antenna is focused only toward transmit site 20.

The use of multiple transmit sites, such as 14 and 16, for the same multiuse microwave signal on the same band, but positioned at different locations about the service area 12 increases the probability that any particular receive site will be able to receive the desired multiuse microwave signal without being "shaded" by intervening objects, such as buildings, trees or hills.

As can be seen in Figure 1, the same band is used in the one service area 12 by two different program providers which supply the multiuse microwave signals A and B. Thus, the spectrum for a single band is being reused within the single geographic area. Heretofore, it has been necessary to provide a very substantial geographical separation distance between transmit sites which operate on the same band.

Referring now to Figure 2, the present invention can be applied to each of a plurality of bands used within a single service area thereby providing reuse of each of the available bands within that service area. Broadcast system 80 uses bands F1 and F2 for a single service area 82, which is identified by the dashed line. As an example, band F1 can be 29-30 gHz and band F2 can be 30-31 gHz.

The broadcast system 80 includes transmit sites 84, 86, 88, 90 and 92. These transmit sites have respective transmit antennas 84A, 86A, 88A, 90A and 92A. The transmit antennas at the sites 84, 86, 88, 90 and 92 have respective beam patterns 96, 98,

100, 102 and 104. Each transmit site produces a beam pattern which substantially encompasses the service area 82.

The transmit sites 84, 86 and 88 use band F1 and transmit sites 90 and 92 use band F2. Transmit sites 84 and 86 broadcast multiuse microwave signal A, site 88 broadcasts multiuse microwave signal B, site 90 broadcasts multiuse microwave signal C and site 92 broadcasts multiuse microwave signal D. By use of the present invention, four different multiuse microwave signals can be currently broadcast to one geographic area on only two bands.

Within the service area 82, there are located a plurality of receive sites 108, 110, 112, 114, 116, 118, 120 and 122. Each receive site is provided with a corresponding narrow beamwidth receive antenna 108A-122A. The receive equipment and bandwidths for the receive sites shown in Figure 2 are the same as those described for Figure 1, but with multiple operating bands used in Figure 2.

The receive sites 108-122 have respective receive antenna beam patterns 126, 128, 130, 132, 134, 136, 138 and 140. Each of these beam patterns is substantially narrower than the beam pattern widths of the transmit antennas.

In Figure 2, the receive sites 108, 110, 114, 118 and 120 receive band F1 and the receive sites 112, 116 and 122 receive band F2.

There are four different multiuse microwave signals A, B, C and D being transmitted by the broadcast system 80 shown in Figure 2. Multiuse microwave signals A and B are carried in band F1 and multiuse microwave signals C and D are carried in band F2. In this described embodiment, there are four different multiuse microwave signals being transmitted in a single service area with only two different bands. As noted above, each band can include a substantial number of channels.

The system of the present invention can also be utilized wherein a single transmit site can broadcast on multiple frequency bands. Thus, the present invention can substantially increase the amount of multiuse microwave signals that can be transmitted on a

given amount of broadcast spectrum. For example, in Figure 2, sites 84 and 90 may be collocated and sites 86 and 92 may be collocated.

A summary chart is given below illustrating the relationship of the transmit sites, the bands used by the transmit sites, the multiuse microwave signals transmitted on each band and the signals received at each receive site.

Transmit Sites	Band	Multiuse Microwave Signal	Receive Sites
84	F1	A	108, 110
86	F1	A	114, 120
88	F1	B	118
90	F2	C	112, 116
92	F2	D	122

In summary, the present invention comprises a broadcast system for transmission of video and any other information to a single service area wherein each available band can be reused to provide additional multiuse microwave services.

One example of allocation, in reference to Figure 2, can have multiuse microwave signal A used for a commercial system, such as subscription television, and multiuse microwave signal B used for educational broadcasting in which case receive site 118 would be a school. In this example, the educational multiuse microwave spectrum is made available by reuse of spectrum allocated to commercial activity.

Although several embodiments of the invention have been illustrated in the accompanying drawings and described in the foregoing detailed description, it would be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the scope of the invention.

CLAIMS:

What we claim is:

1. A broadcast system for providing multiple multiuse microwave signals concurrently on a single band to a unitary service area, comprising:

one or more first multiuse microwave signal transmit sites, each of which has a transmit antenna for line-of-sight broadcasting on said band to said service area,

one or more second multiuse microwave signal transmit sites each of which has a transmit antenna for line-of-sight broadcasting on said band to said service area, wherein said first multiuse microwave signal is different from said second multiuse microwave signal,

a plurality of receive sites within said service area, each receive site having a directional antenna having a beamwidth less than the beamwidth of said transmit antennas,

a first set of said receive sites wherein each receive site in said first set has the directional antenna thereof focused toward one of the transmit antennas for said first multiuse microwave signal transmit sites for receiving said first multiuse microwave signal,

a second set of said receive sites wherein each receive site in said second set has the directional antenna thereof focused toward one of the transmit antennas for said second multiuse microwave signal transmit sites for receiving said second multiuse microwave signal, and

said first and said second multiuse microwave signal sites located sufficiently distant from each other such that only one of said multiuse microwave signal transmit sites is within the beam of any one of said receive site directional antennas.

2. A broadcast system for providing multiple multiuse microwave signals as recited in Claim 1 wherein each of said transmit antennas has a beamwidth of less than 180°.

3. A broadcast system for providing multiple multiuse microwave signals as recited in Claim 1 wherein each of said multiuse microwave signals has a plurality of channels.

4. A broadcast system for providing multiple multiuse microwave signals as recited in Claim 1 wherein each of said transmit sites is located along the periphery of said service area.

5. A broadcast system for providing multiple multiuse microwave signals as recited in Claim 1 wherein there are two of said first multiuse microwave signal transmit sites and there are two of said second multiuse microwave signal transmit sites.

6. A broadcast system for providing multiple multiuse microwave signals concurrently on each of a plurality of bands to a unitary service area, comprising:

one or more first multiuse microwave signal transmit sites, each of which provides line-of-sight broadcasting on a first of said bands to said service area,

one or more second multiuse microwave signal transmit sites each of which provides line-of-sight broadcasting on said first band to said service area, wherein said first multiuse microwave signal is different from said second multiuse microwave signal,

one or more third multiuse microwave transmit sites, each of which provides line-of-sight broadcasting on a second of said bands to said service area,

one or more fourth multiuse microwave signal transmit sites each of which provides line-of-sight broadcasting on said second band to said service area, wherein said third multiuse microwave signal is different from said fourth multiuse microwave signal,

a plurality of receive sites within said service area, each receive site having a directional antenna having a beamwidth less than that of said transmit antennas,

a first set of said receive sites wherein each receive site in said first set has the directional antenna thereof focused toward one of the transmit antennas for said first multiuse microwave signal transmit sites,

a second set of said receive sites wherein each receive site in said second set has the directional antenna thereof focused toward one of the transmit antennas for said second multiuse microwave signal transmit sites,

a third set of said receive sites wherein each receive site in said third set has the directional antenna thereof focused toward one of the transmit antennas for said third multiuse microwave signal transmit sites,

a fourth set of said receive sites wherein each receive site in said fourth set has the directional antenna thereof focused toward one of the transmit antennas for said fourth multiuse microwave signal transmit sites,

said first and said second multiuse microwave signal transmit sites sufficiently distant from each other such that only one of said first and second multiuse microwave

signal transmit sites is within the beam of any one of said first and second receive site directional antennas and said third and fourth multiuse microwave signal sites sufficiently distant from each other such that only one of said third and fourth multiuse microwave signal transmit sites is within the beam of any one of said third and fourth receive site directional antennas.

7. A broadcast system for providing multiple multiuse microwave signals as recited in Claim 6 wherein each of said multiuse microwave signal sites has a transmit antenna which has a beamwidth of less than 180 degrees.

8. A broadcast system for providing multiple multiuse microwave signals as recited in Claim 6 wherein each of said multiuse microwave signals has a plurality of channels.

9. A broadcast system for providing multiple multiuse microwave signals as recited in Claim 6 wherein said first and third multiuse microwave signal transmit sites are collocated and said second and fourth multiuse microwave signal transmit sites are collocated.

10. A broadcast system for providing multiple multiuse microwave signals as recited in Claim 6 wherein each of said transmit sites is located along the perimeter of said service area.

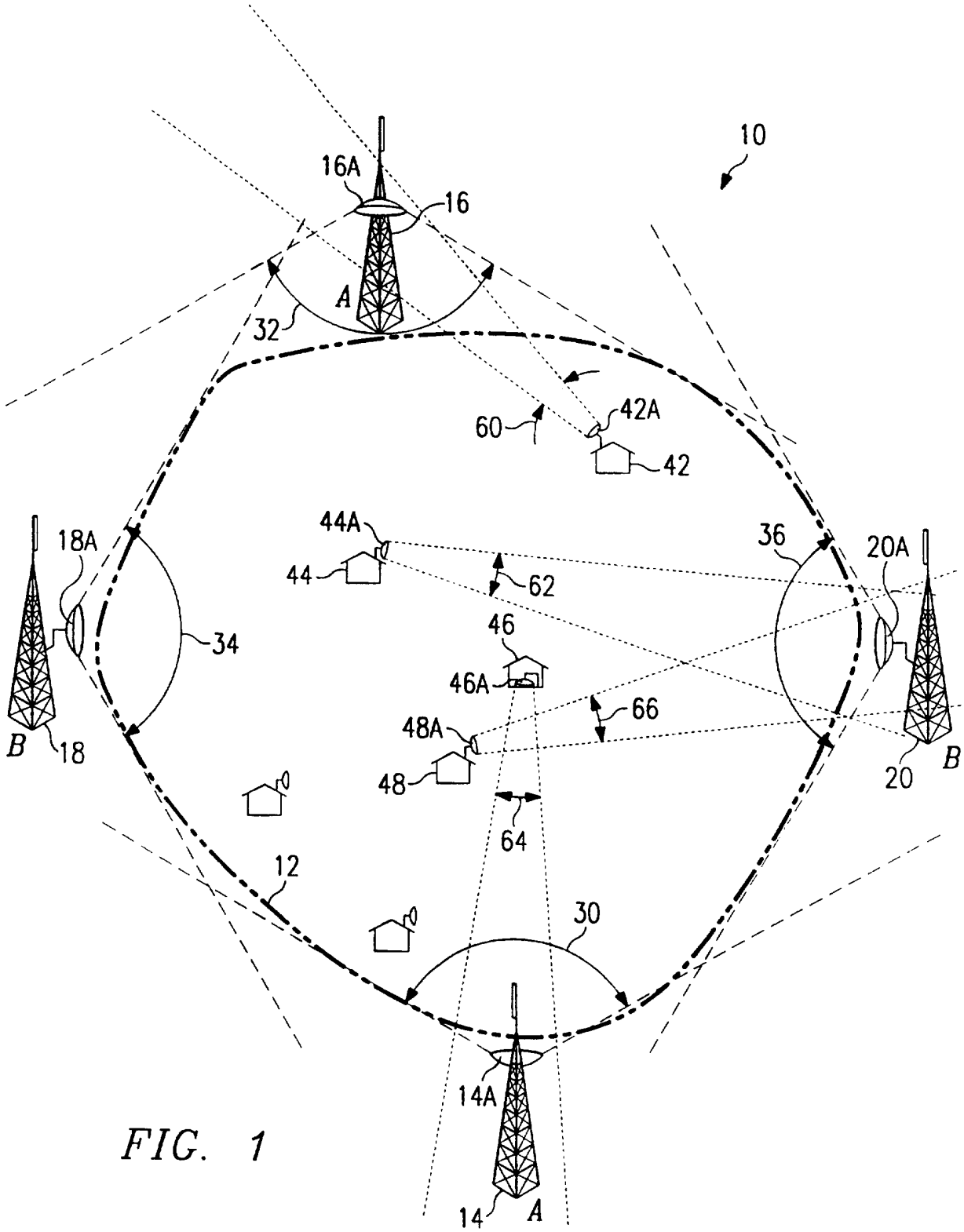
10
16A
16
A
32
60
42A
42
44A
44
62
36
20A
18A
34
46
46A
66
48A
48
64
B
18
20
B
12
30
14A
14
A

FIG. 1

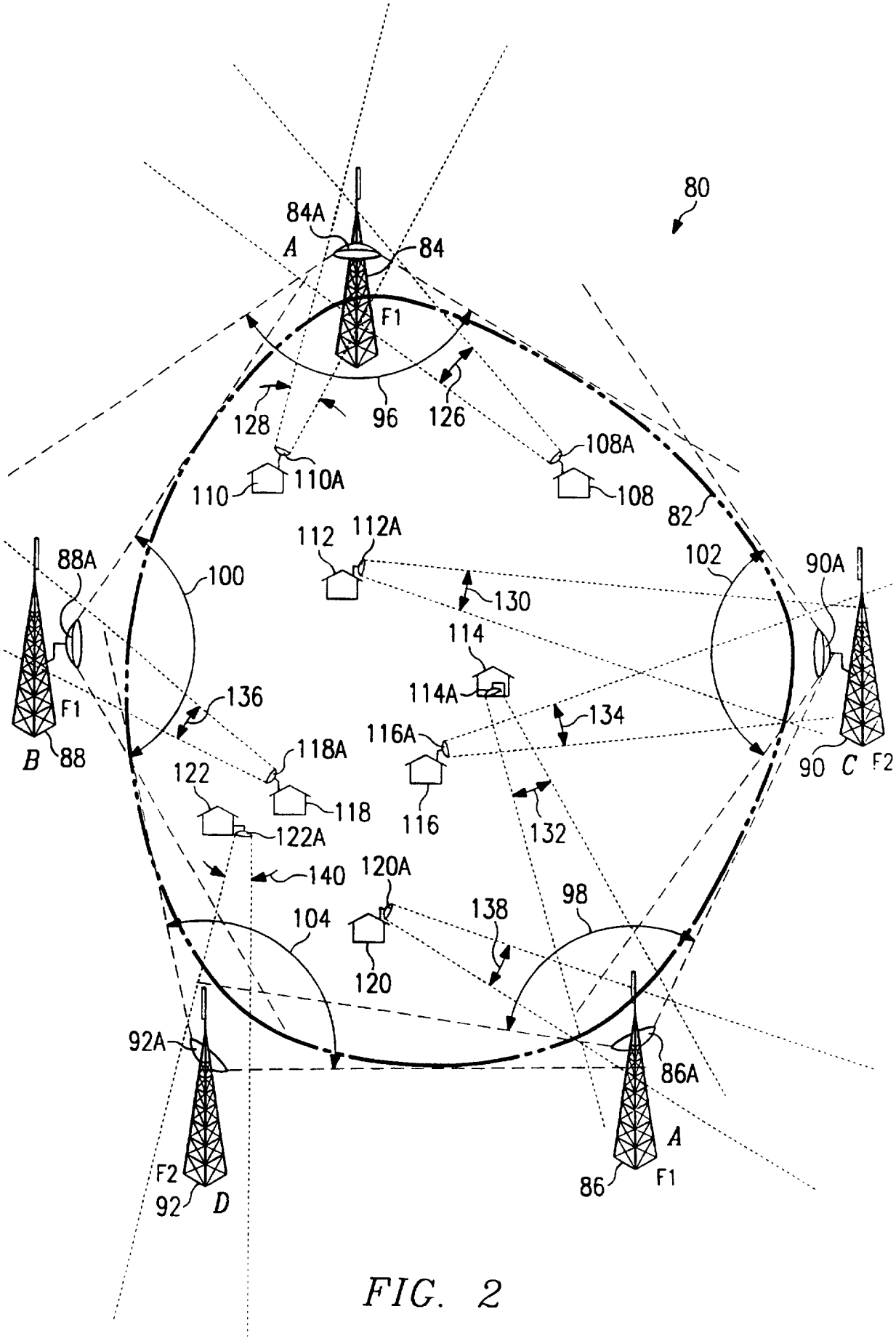
80
84A
A
84
F1
128
96
126
108A
110
110A
108
82
112
112A
102
88A
100
130
90A
114
114A
136
134
F1
116A
B
88
118A
90
C
F2
122
118
116
122A
132
140
120A
104
138
98
120
92A
86A
A
F2
86
F1
92
D

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/07307

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04B 7/06
US CL :455/49.1

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)

U.S. : 455/49.1, 51.2, 57.1, 3.1, 3.2, 4.2, 6.1, 6.3

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)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,255,814 A (OSBORN) 10 March 1981, fig. 1; col. 1, lines 15-35, 45-47; col. 2, lines 1-16.	1-10
Y	US 5,345,599 A (PAULRAJ ET AL) 06 September 1994, fig. 2; col. 3, lines 59-68; col. 4, lines 1-19; col. 7, lines 14-35.	1-10
A	US 4,528,656 A (MORAIS) 09 July 1985, col. 1, lines 15-27; col. 2, lines 24-34.	1-10
A	US 4,928,177 A (MARTINEZ) 22 May 1990, col. 1, lines 64-65; col. 2, lines 29-42.	1-10
A	US 5,214,787 A (KARKOTA, JR.) 25 May 1993, col. 1, lines 23-29; col. 2, lines 25-31, 38-43.	1-10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/07307

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 5,437,052 A (HEMMIE ET AL) 25 July 1995, fig. 1; col. 1, lines 19-23, 35-36, 46-50; col. 3, lines 55-68 through col. 4, lines 1-52.	1-10
A,P	US 5,559,808 A (KOSTRESKI ET AL) 24 September 1996, figs. 1 and 1A; col. 1, lines 25-29, 35-40, 54-55; col. 2, lines 1-4, 13-22;	1-10
A	US 4,347,626 A (WENZEL) 31 August 1982, fig. 1; col. 1, lines 55-68 through col. 2, lines 1-24 and lines 48-53.	1-10
A	US 5,287,550 A (FENNELL ET AL) 15 February 1994, col. 1, lines 20-23, 35-39; col. 2, lines 25-30.	1-10