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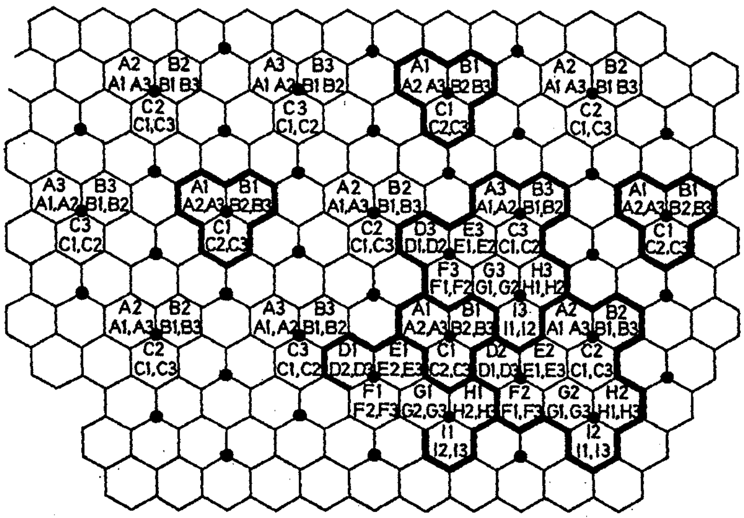

(57) Abstract

The invention relates to an arrangement for frequency planning in cellular systems using a mix of wide and narrow antenna beams. The arrangement employs a dual frequency reuse for the respective wide and narrow antenna beams. According to the invention, a first frequency group is allocated to a cluster with a reuse distance sufficient for narrow beam channels and a second frequency group is allocated to a larger cluster with a reuse distance sufficent for wide beam channels. The second frequency group is a subdivision of and contained in the first frequency group. The second frequency group is the only frequency group available for wide beam channels, while all the frequencies of the two groups are available for the narrow beams channels. Generally, the wide beams are used for control channels and the narrow beams are used for traffic channels. A frequency planning in accordance with the invention makes it possible to use narrow beam traffic channels more efficiently compared to known state of the art methods which results in improved trunking efficiency.

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ARRANGEMENT FOR FREQUENCY PLANNING IN CELLULAR SYSTEMS

Field of the invention

The present invention relates to an arrangement for frequency planning in cellular systems using a mix of wide and narrow antenna beams. The arrangement employs a dual frequency reuse for the respective wide and narrow antenna beams. Generally, the wide beams are used for control channels and the narrow beams are used for traffic channels. A frequency planning in accordance with the invention makes it possible to use narrow beam traffic channels more efficiently compared to known state of the art methods which results in improved trunking efficiency.

State of the art

In cellular systems using phased array antennas at the base station, signals from the mobile stations are normally received and transmitted through narrow antenna beams. The control channels, however, which are used for transmitting e.g. broadcast information and page messages in the downlink, or random access messages in uplink, can typically not be transmitted in narrow antenna beams. The reason for this is that many cellular standards require that the control channels be continously transmitted over the entire coverage area of the radio cell. The control channels must therefore be transmitted using a wide antenna beam that covers the radio cell. See e.g. US 4,723,266.

The traffic channels, which are transmitted and received in narrow antenna beams, can be frequency planned using a tight frequency reuse since the narrow antenna beams will reduce the interference. The control channels, which are transmitted using wide antenna beams, must be planned using a larger frequency reuse.

In certain cellular standards, such as e.g. the Nordic Mobile Telephone (NMT) system, it is not possible to designate specific channels (frequencies) as control channels. The Mobile Telephone Exchange (MTX) allocates any of the available channels within a cell to serve as a control channel.

In cellular systems of this type, using phased array antennas, the available spectrum is usually divided into to two parts, in order to handle different frequency reuse patterns. One method that can be used is to assign two "logical" base stations to each cell. The method is described in our pending Swedish patent application 9703939-0. The first logical base station (here denoted as BS_{type1}) comprises channels from the part of the frequency spectrum that has been reserved for wide beam channels, while the second base station (here denoted as BS_{type2}) comprises channels from the part of spectrum that has been reserved for narrow beam channels. BS_{type1} and BS_{type2} cover the same geographical area.

When a call is being set up, the mobile station and the network (base station and MTX) first communicates on a control channel. The network then allocates a traffic channel and orders the mobile station to switch to that channel. In most cellular systems the allocated traffic channel must belong to the same logical base station as the control channel (i.e. BS_{type1} in this example). After the call has been set up, a handover can be performed in order to switch the call to another base station (e.g. BS_{type2}). From this description it can be seen that BS_{type1} must comprise at least two channels; one control channel and at least one traffic channel. In order to avoid congestion, several traffic channels will normally be needed in BS_{type1}.

Since any channel in BS_{type1} can be used as (wide beam) control channel, all channels allocated to BS_{type1} must be frequency planned using a large frequency reuse. Thus, in the prior art systems, a relative large portion of the spectrum is set aside and planned with a large frequency reuse, which results in relatively low capacity. Furthermore, the number of channels remaining for BS_{type2} will be rather small, resulting in poor trunking efficiency in these base stations.

The present invention solves this problem in a cellular system of the type described above, having a mix of wide and narrow beams. The available frequency band is arranged in two frequency groups having different reuse distances. One group has a tight reuse suitable for narrow beams and a second group has a larger reuse distance suitable for wide beams. The group reserved for wide beams is a sub-division of the first group and may also be used by narrow beam channels with tighter reuse. Thus, more channels are available for the narrow beam traffic channels resulting in improved trunking efficiency and a higher traffic capacity.

Summary of the invention

The present invention relates to an arrangement for frequency planning in a cellular system using wide antenna beams and narrow antenna beams and having a given frequency band.

According to the invention, a first frequency group is allocated to a cluster with a reuse distance sufficient for narrow beam channels and a second frequency group is allocated to a larger cluster with a reuse distance sufficient for wide beam channels. The second frequency group is a subdivision of and contained in the first frequency group. The second frequency group is the only frequency group available for wide beam channels, while all the frequencies of the two groups are available for the narrow beam channels.

The invention is defined in the attached claim 1, while preferred embodiments are set forth in the dependent claims.

Brief description of the drawings

The invention will be described below with reference to the accompanying drawings, in which:

figure 1 is a schematic representation of a cell planning pattern according to one embodiment of the invention, and

figure 2 is an explanation of the symbols in figure 1.

Detailed description of preferred embodiments

As is mentioned previously, cellular systems with a mix of wide and narrow antenna beams are known per se. Thus, the characteristics and advantages of such systems are not described in detail here. The present invention is mainly dealing with frequency planning aspects of such systems. The invention may be applied in analog or digital systems. Nor is the invention limited to any specific frequency range or band.

The cellular system comprises base stations communicating with mobile terminals. Generally, one base station is located at one site. When describing the invention each base station site is assumed to be a tri-sector site. That is, each site serves three 120 degrees sectors (or cells). The invention can however also be applied for other site configurations.

The available channels are divided into n_1 frequency groups, where n_1 corresponds to the cluster size for the channels using narrow antenna beams, i.e. one group per cell. The cluster size, n_1, depends on the cellular standard and on the characteristics of the phased array antenna.

Each frequency group is then divided into k sub-groups, where k is chosen such that $n_2 = n_1 * k$ is a valid frequency reuse pattern. (In a valid frequency reuse pattern, n must fulfil $n=a^2+b^2+a \times b$, where a and b are integers.) For a system using tri-sector sites, n_2 must also be divisible by 3 (or a number greater than 3).

In each cell, one specific sub-group is allocated for the channels that use wide antenna beams. Since there are a total of n_2 sub-groups, the channels using wide antenna beams can be planned with a reuse that corresponds to a cluster size of n_2. Note that all the channels in the sub-group allocated for wide antenna beams are not required to use wide antenna beams. Only the control channels will use wide antenna beams, while the traffic channels use narrow beams. In other words, if a channel in the sub-group allocated for wide antenna beams is not used but free, it may be used with a narrow beam for a traffic channel. Thus, all free channels of a group including sub-groups are available for narrow beam traffic channels. Usually, one or two channels are occupied as wide beam control channels.

Using the frequency planning method described in this document, a channel using a wide antenna beam will experience interference from other co-channels using wide antenna beams located at reuse distances $\geq n_2$. The channel will also experience interference from channels using narrow antenna beams located at reuse distances $\geq n_1$.

The method is illustrated in figure 1 for the case where n_1=9 and k=3. The 9 frequency groups are denoted A, B,..., I and the three sub-groups of e.g. frequency group A are denoted A1, A2 and A3. As is shown in figure 2, the numeral at the top of each cell denotes the sub-group allocated to the wide antenna beams, while the two lower numerals denote the sub-groups allocated to the narrow antenna beams.

If we only look at the main groups, i.e. ignore the indexes identifying the sub-groups, we see that contiguous clusters of 9 cells are identical. These clusters relate to the narrow antenna beams and due to this fact, there is sufficiently low interference because of the lower interference experienced with narrow antenna beams. The fact that some of the frequencies used for narrow beams actually belong to a sub-group also used by wide beams does not alter this situation.

However, if we look at the sub-groups we see that the top sub-group in each cell allocated to wide antenna beams, is different in contiguous clusters of 9 cells and instead identical clusters of 27 cells are formed. This ensures that the reuse distance is increased sufficiently for wide antenna beams.

In systems using the logical base stations outlined above, the frequency subgroups are allocated to base stations of type 1 and the rest of the frequencies are allocated to base stations of type 2. However, the invention as such does not require the separation into different logical base stations.

Example

The advantages of the present invention are illustrated by a comparison between a typical cell planning in an NMT system in which a mix of wide and narrow beams has been introduced and a system utilizing the present invention. We assume a total of 180 channels are available in both systems. The narrow beam cluster size is 3/9 (i.e. reuse distance/number of cells), while the wide beam cluster size is 7/21 for NMT and 9/27 for the invention, respectively. (If the NMT system would use a larger 9/27 cluster, the interference situation would be improved but the trunking efficiency would be even smaller, since more channels would be separated from the planning of the small cluster.) As is mentioned above, a first logical base station (here denoted as BS_{type1}) comprises channels from a part of the frequency spectrum that has been reserved for wide beam channels, while the second base station (here denoted as BS_{type2}) comprises channels from the part of spectrum that has been reserved for narrow beam channels. BS_{type1} and BS_{type2} cover the same geographical area.

In the NMT system, four channels are allocated to base station type 1 to reduce the risk of congestion or blocking of the control channels. These are planned in a large 7/21 cluster. These 4×21=84 channels are subtracted from the 180 channels. Thus, 180-84=96 channels are allocated to the smaller 3/9 cluster, that is ≈10 (actually for some 10 and some 11) in each cell. The total number of available channels in each cell is 10+4 of which one or two normally are occupied for a wide beam control channel. Thus, the trunking efficiency is based on ≈13 channels.

In the present invention, the 180 channels are divided into 9 first groups for the smaller 3/9 cluster, that is 180/9=20 channels. These first groups are in turn subdivided into three second subgroups each (e.g. 7+7+6=20) available as wide beam control channels. The 9×3=27 subgroups are planned in a large 9/27 cluster. The total number of available channels in each cell is still the maximum 20, but of which 6 or 7 are planned in a large 9/27 cluster and of which one or two normally are occupied for a wide beam control channel. Thus, the trunking efficiency is based on ≈19 channels. Since the subgroups are contained in the first groups, the subgroups are not subtracted from the first groups but only planned differently. Thus, the available pool of channels is increased, resulting in an increased trunking efficiency.

Thus, it will be seen that the arrangement according to the invention uses the narrow beam traffic channels more efficiently compared to known state of the art methods. This leads to higher trunking efficiency and thus a higher traffic capacity.

The invention has been described with respect to a cellular system using tri-sector sites and a narrow beam cluster size of 9 cells. A person skilled in the art will realize that the invention is equally applicable to other types of base stations and cell planning schemes. The invention is only limited by the claims below.

CLAIMS

1. An arrangement for frequency planning in a cellular system using wide antenna beams and narrow antenna beams and having a given frequency band, **characterised** in that a first frequency group is allocated to a cluster with a reuse distance sufficient for narrow beam channels, a second frequency group is allocated to a larger cluster with a reuse distance sufficient for wide beam channels, said second frequency group being a subdivision of and contained in the first frequency group, wherein the second frequency group is the only frequency group available for wide beam channels, while all the frequencies of the two groups are available for the narrow beam channels.

2. An arrangement according to claim 1, **characterised** in that the first frequency group is assigned to a first logical base station in each cell and the second frequency group is assigned to a second logical base station in each cell for the handling of the narrow and wide antenna beams, respectively.

3. An arrangement according to claim 1 or 2, **characterised** in that the cellular system employs tri-sector sites, wherein the first frequency group is allocated to a cluster with a size of 9 cells and the second frequency group is the first group divided by 3 and allocated to a cluster with a size of 27 cells.

4. An arrangement according to any one of the preceding claims, **characterised** in that wide antenna beams are used for control channels and narrow antenna beams are used for traffic channels.

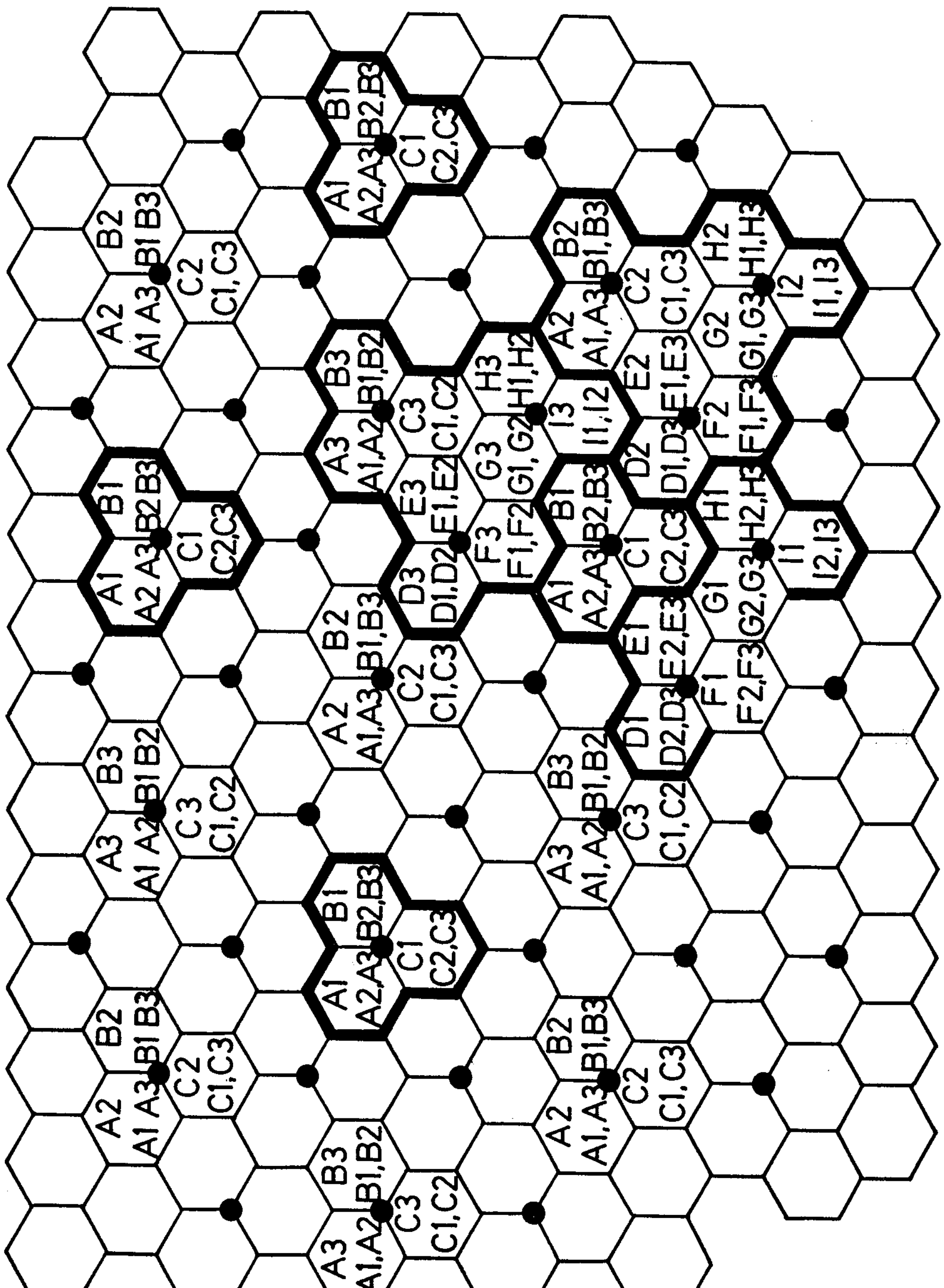

FIG. 1

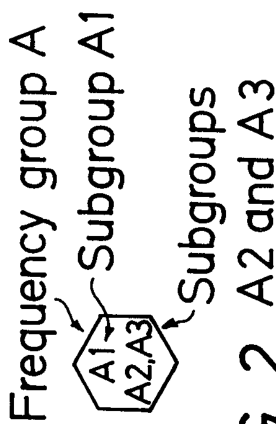

FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/00215

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04Q 7/38, H04Q 7/36
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)

IPC7: H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, 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.
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A	US 5615409 A (ULF FORSSEN ET AL), 25 March 1997 (25.03.97), column 3, line 30 - line 52	1-4
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A	US 4723266 A (FRED G. PERRY), 2 February 1988 (02.02.88), abstract	1-4
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

02/12/99

International application No.
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