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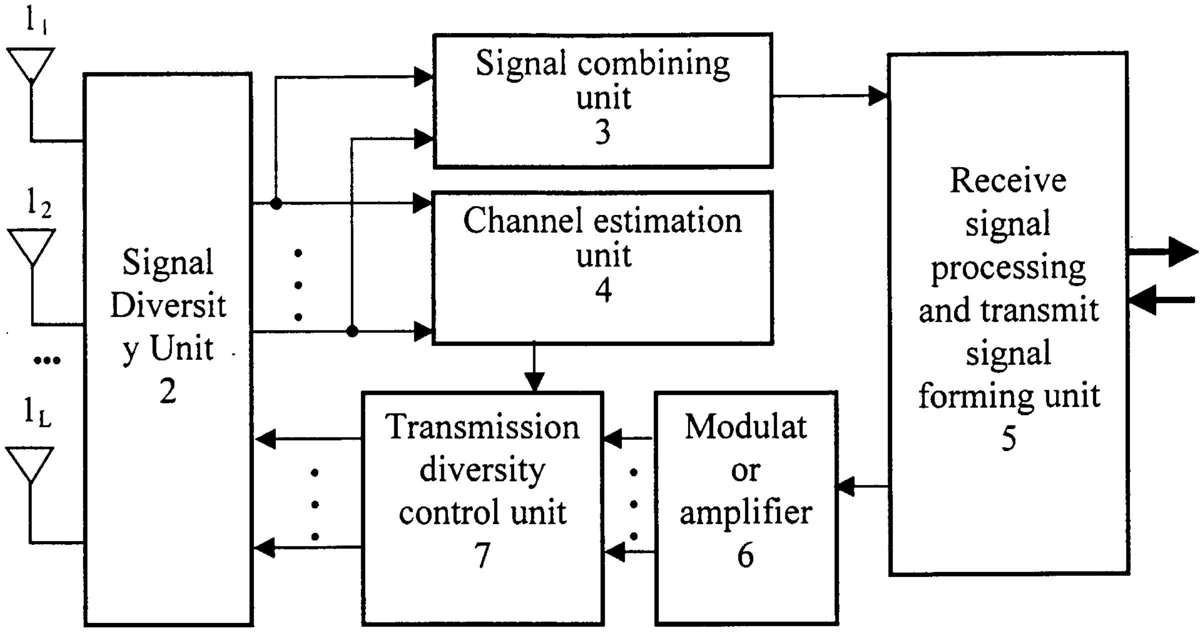

Fig. 1

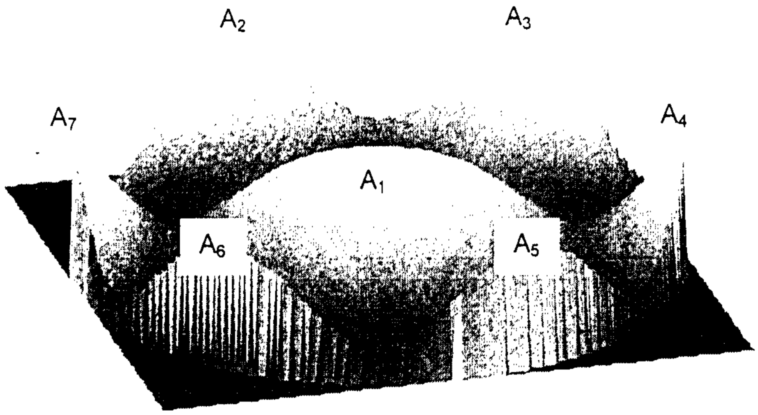

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Fig. 2A

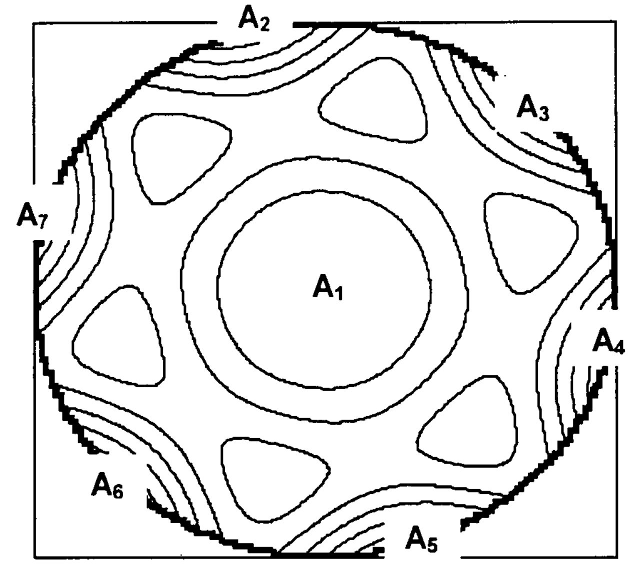


Fig. 2B

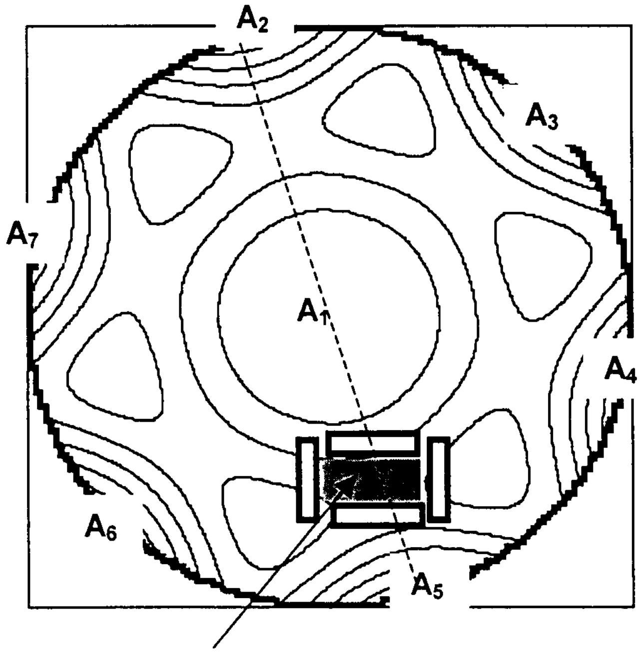


Fig. 2C

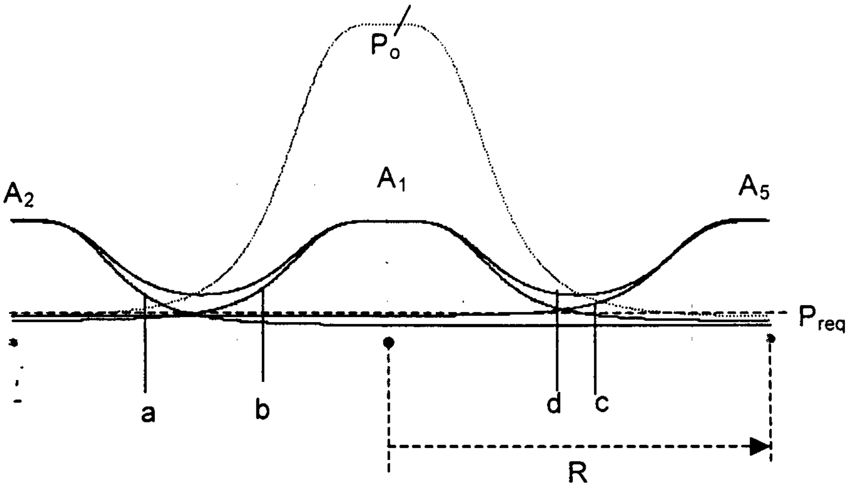


Fig. 3A

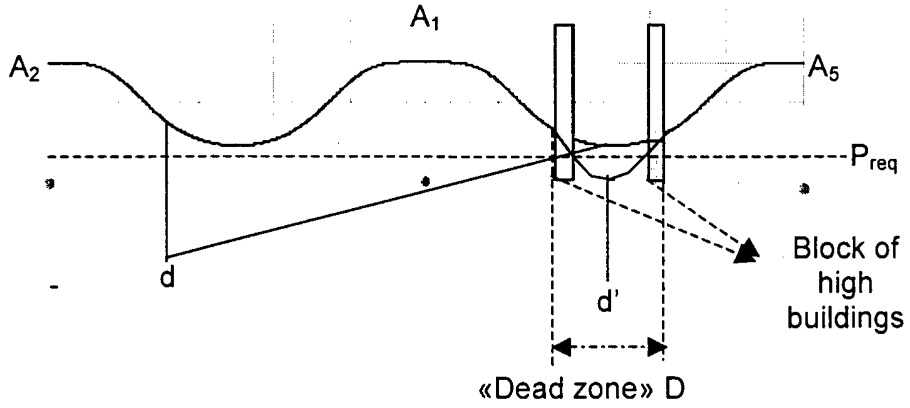


Fig. 3B

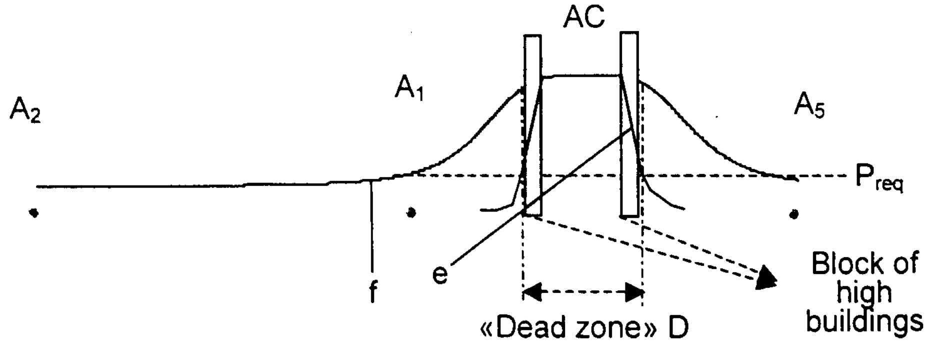


Fig. 3C

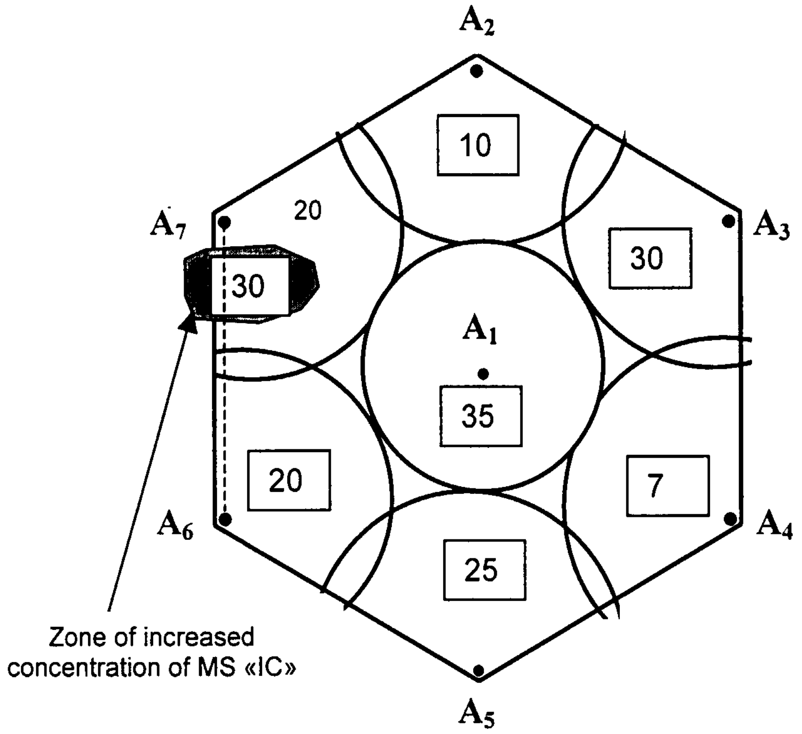

A₂
10
A₇
20
30
A₃
30
A₁
35
20
7
A₆
A₄
25
A₅
Zone of increased concentration of MS «IC»

Fig. 4

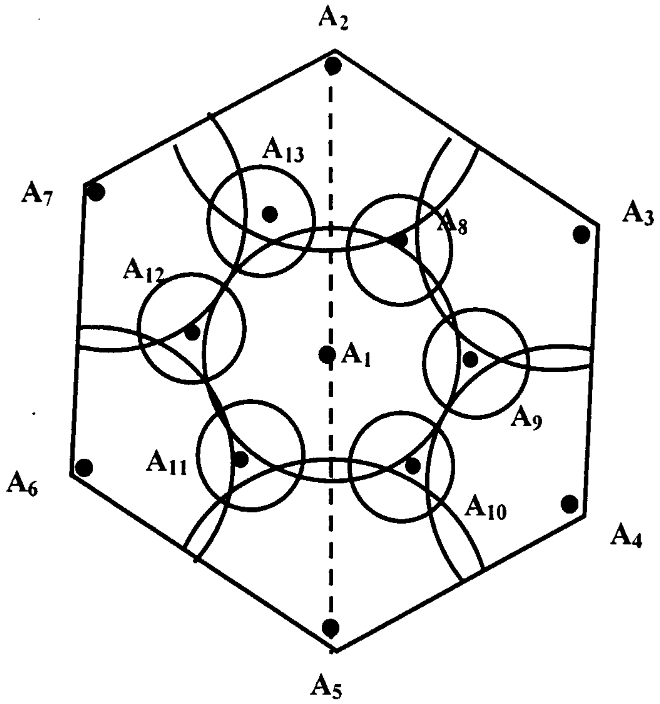

A_2
A_{13}
A_7
A_3
A_8
A_{12}
A_1
A_9
A_{11}
A_6
A_{10}
A_4
A_5

Fig. 5A

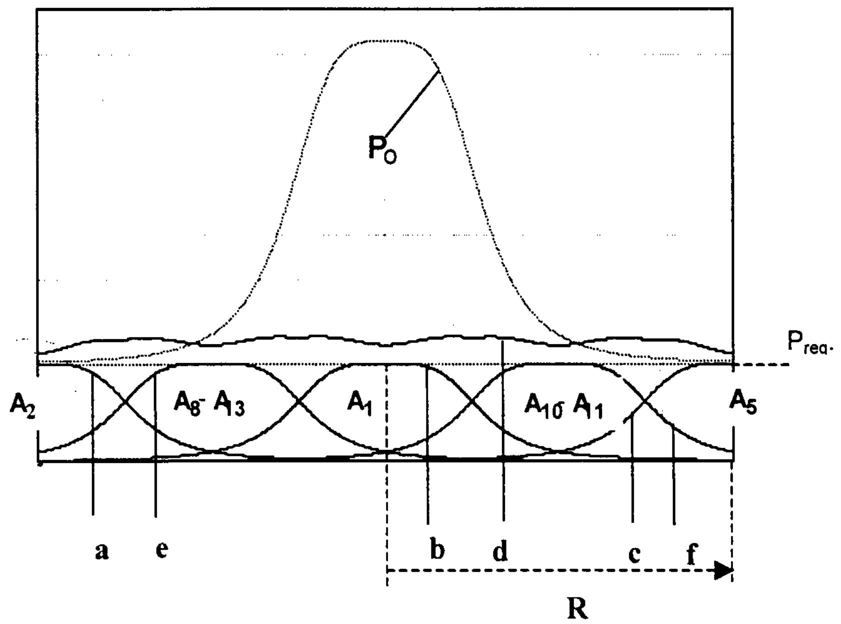

P_0
$P_{req.}$
A_2
A_8- A_{13}
A_1
A_{10}- A_{11}
A_5
a
e
b
d
c
f
R

Fig. 5B

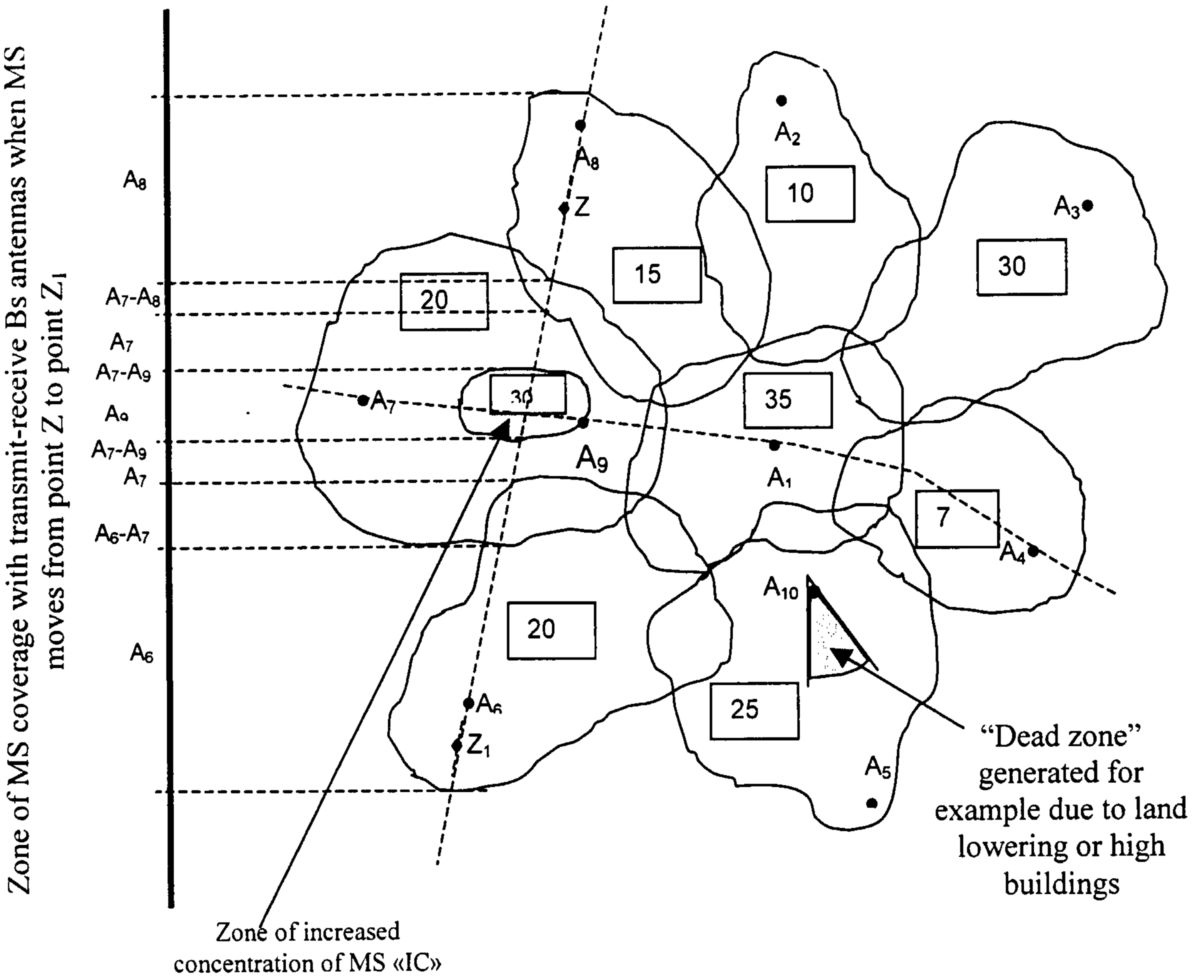

Zone of MS coverage with transmit-receive Bs antennas when MS moves from point Z to point Z_1
A_8
A_7-A_8
A_7
A_7-A_9
A_9
A_7-A_9
A_7
A_6-A_7
A_6
A_2
10
A_3
30
A_8
Z
15
20
30
35
A_7
A_9
A_1
7
A_4
A_{10}
20
25
A_6
Z_1
A_5
"Dead zone" generated for example due to land lowering or high buildings
Zone of increased concentration of MS «IC»

Fig. 6A

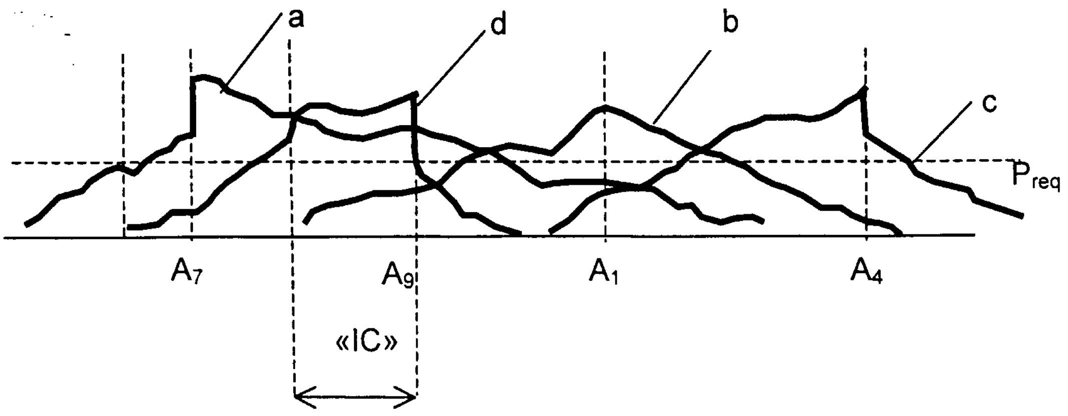

a
d
b
c
P_{req}
A_7
A_9
A_1
A_4
«IC»

Fig. 6B

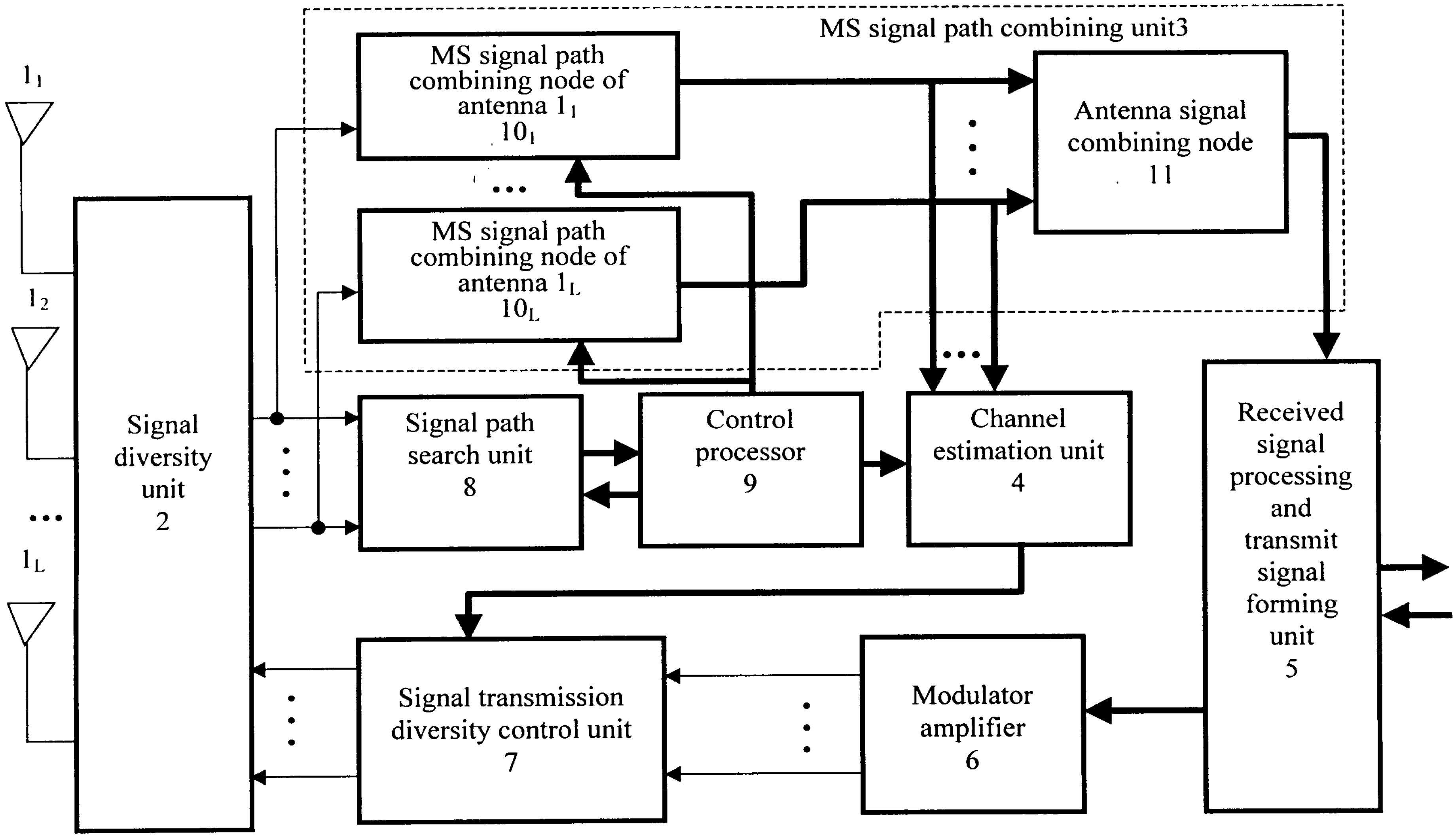
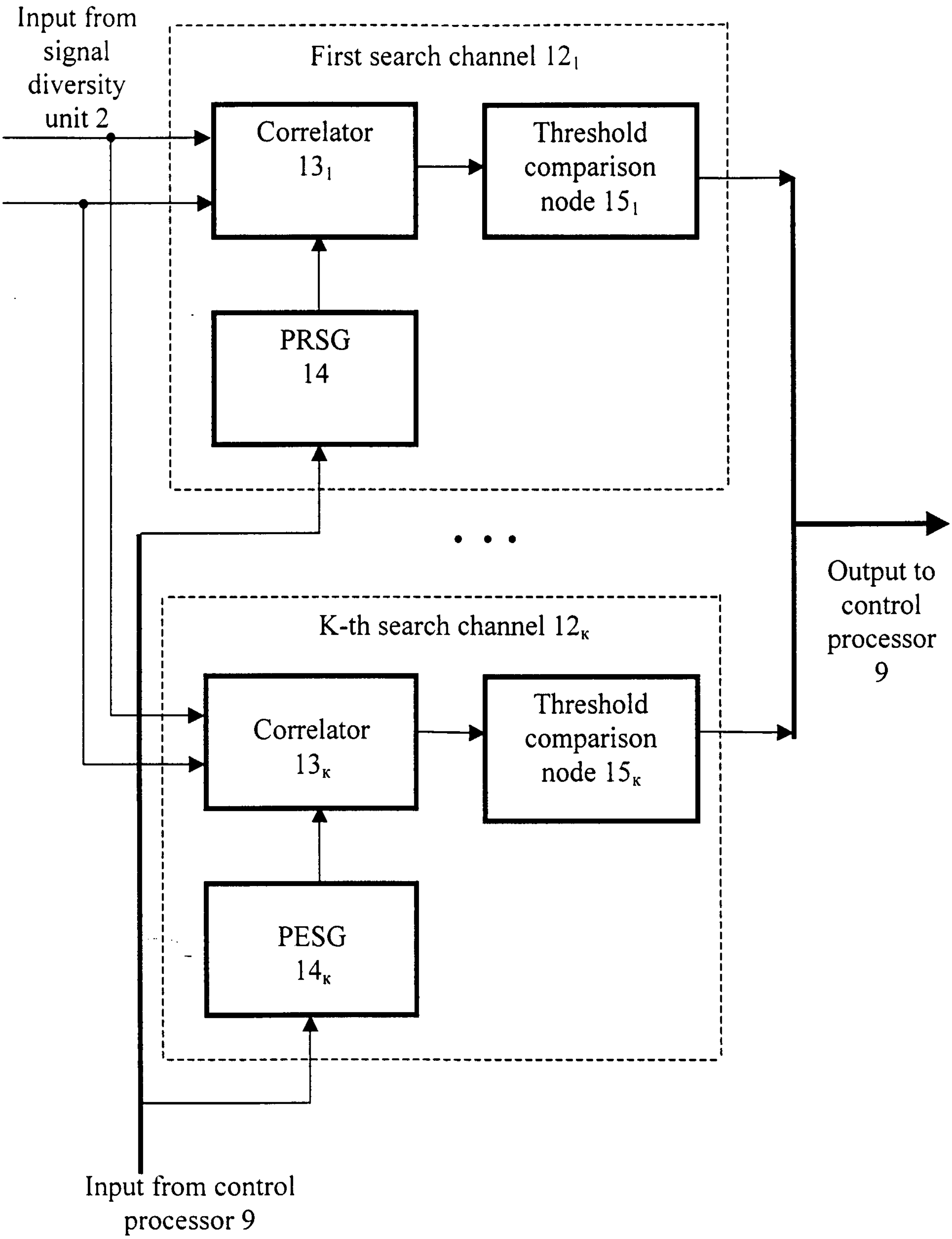

MS signal path combining unit3
1_1
1_2
1_L
Signal diversity unit 2
MS signal path combining node of antenna 1_1 10_1
MS signal path combining node of antenna 1_L 10_L
Antenna signal combining node 11
Signal path search unit 8
Control processor 9
Channel estimation unit 4
Received signal processing and transmit signal forming unit 5
Signal transmission diversity control unit 7
Modulator amplifier 6

Fig. 7



Input from signal diversity unit 2
First search channel 12_1
Correlator 13_1
Threshold comparison node 15_1
PRSG 14
• • •
Output to control processor 9
K-th search channel 12_K
Correlator 13_K
Threshold comparison node 15_K
PESG 14_K
Input from control processor 9

Fig. 8

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METHOD OF RADIO INTERFACE ORGANIZATION AND BASE STATION IN CELLULAR COMMUNICATION SYSTEM

The present invention relates to a method of radio interface organisation in a cellular communication system, and a base station.

The present invention relates in preferred embodiments to radio engineering, and more particularly to the method of radio interface organization and base station equipment in CDMA communication system, which provide continuous connection between mobile stations (MS) and base station (BS).

A mobile cellular radio communication system should serve a maximal number of simultaneously operating mobile stations with the specified quality of transmit and receive information, i.e. provide the maximal system capacity. At the same time, it is necessary to provide a minimal level of mutual interference both between MS and cells. This can be achieved, first, by reducing the power of BS and MS transmit-receive antenna electromagnetic radiation to the minimum acceptable level and, second, by optimal placing BS transmit-receive antennas and orientation of their antenna patterns.

The book (see Ratynski M.V. Basics of Cellular Communication, Library of Cellular Communication series, BEELINE Cellular Communication, Moscow, Radio and Communication, 2000 (pp. 19-24, 55-57) contains a systematic overview of the basic aspects of modern cellular communication, conventional description and schematic presentation of a standard communication system, description and illustration of the procedure of a mobile station handoff by base stations when crossing cell borders.

Under conditions of limited bandwidth of operation frequencies assigned to mobile communication systems, the number of users can be increased through repeated use of operation frequencies, space and time diversity of the radiated signals, and application of effective modulation methods.

There is no universal solution to this task. In each specific case it should be treated differently.

An invention has been proposed (see WO 98/12889 "Base Station and Process of Powering a Cell of a Cellular Mobile Radio System", H 04

Q 7/36, H 04 B 7/06, published March 26, 1998), which describes the method and device of radio interface organization in GSM system (Global System for Mobile Communication).

There are two possible embodiments of this invention aimed to increase overall system capacity:

according to the first embodiment, additional space diversity of BS transmit-receive antennas is performed at the cell periphery;

according to the second embodiment, sectorization of BS transmit-receive antenna, located in the cell center, is carried out.

According to the first embodiment of the solution, *L* BS transmit-receive antennas are placed at the cell periphery. Communication channels between BS and MS are formed, thus providing additional space diversity of BS signal. When organizing radio interface between BS and MS, time and frequency multiplexing is used.

To serve *N* simultaneously operating MS by all *L* BS transmit-receive antennas, there should be *N* different carrier frequencies at all BS transmit-receive antennas. From the description of the given invention it follows that the number of carrier frequencies can be reduced through their switching by planning the load of each channel of diversity reception from BS to MS. The channel load depends on specific characteristics of each cell. Depending on the channel load, the required number of BS transmit-receive antennas is determined. BS channels are connected or disconnected depending on the quality of signal transmission via BS-MS connection on the whole, when the quality of signal transmission is evaluated by all communication channels or by the quality of signal transmission in separate channels. In case of inappropriate connection quality, additional BS channels can be connected or the channels with the worst transmission quality can be removed. Thus the economy of carrier frequencies is achieved in order to provide connection with a larger number of end users.

According to the second embodiment of the solution, BS contains sector transmit-receive antennas located in the cell center. Sector transmit-receive antennas form BS channels and are oriented in such a way that the cell to which BS belongs is divided into sectors. In this case, sectors of separate neighboring BS transmit-receive antennas are overlapped in such a way that one MS could be connected to at least two sector transmit-receive antennas.

Such cell division into sectors allows reducing mutual influence of signals from neighboring sectors, thus reducing the amount of mutual interference. It also allows using one and the same carrier frequency for MS in different non-overlapping sectors.

To implement this algorithm, BS sector antennas are connected to separate transceivers. Transceivers, in their turn, are connected to switching device by means of which sector antenna channels are selected through commutation and their switch, i.e. control, is carried out depending on the load.

With this structure of cellular communication system, owing to BS channel switching, the number of frequency channels in BS transmit-receive sector antennas, involved in a communication session with a specific MS, becomes reduced. BS transmit-receive sector antennas which are not used in a communication session with a given MS become disconnected and are used for other purposes, for example, connection with other MS. Hence, the present technical solution provides cell resource economy and increases system capacity by means of additionally assigned frequency band.

However, placing BS transmit-receive antennas at the cell periphery only, as proposed in the mentioned method, in real operation conditions means the following disadvantages:

– irregular distribution of BS transmit-receive antenna electromagnetic radiation power within a cell and occurrence of signal shadow areas, the so called “dead zones”, where no connection between BS and MS is possible (see Microwave Mobile Communications. Edited by William C. Jakes. Reissued in cooperation with the IEEE Communications Society. Press NY, 1994, chapters 2, 7).

– low quality of connection between BS and MS in the zones of depression of the electromagnetic radiation field strength, thus requiring increased radiation power of BS and MS transmit-receive antennas;

– impossibility to provide the required, i.e. potential, cell capacity in case of irregular MS distribution across the cell square.

The proposed sectorization of BS transmit-receive antenna radiation, located in the cell center, with the specified radio interface organization does not eliminate essential interference of BS and MS signals from neighboring cells.

The structure of the cellular communication system and control algorithm proposed in the above technical solution are not universal and designed for GSM standard systems only.

CDMA base station equipment (see patent US № 5,103,459 «System and Method for Generating Signal Waveforms in a CDMA Cellular Telephone System», Fig. 2, Int. Cl.^{5} H 04 L 27/30) has been proposed, which contains device for MS signal reception and device for signal transmission. Device for MS signal reception consists of two receive antennas intended for MS signal reception and two corresponding analog-digital receivers, at least two searchers and three data receivers, signal combining unit with a decoder, control processor, and digital data transmission channel. Device for BS signals transmission contains sequentially connected modulator, power control unit, summator, transmitter power amplifier connected to pilot signal unit, and antenna for information transmission in the reverse channel.

The mentioned device operates in the following way. A group signal, which is a sum of mobile station signals, located within the service zone of a given receive antenna, arrives at each BS receive antenna. Group signal energy at the input of each BS receive antenna equals the sum of signal energies from each of MS and is an average characteristic of the communication channel. In the analog-digital receiver, these signals are transformed into a digital form and supplied to the input of searchers and data receivers. Searchers scan the uncertainty area and detect MS signals. Having detected MS signal, searchers pass the information to control processor. Control processor estimates the information signals supplied from receivers and passes control signals to data receivers. Data receivers process the received signal through control signal and pass the processed signal to signal combining unit with decoder. Signal combining unit with decoder performs operations of diversity reception of signals from each specific MS, supplied from data receivers, decodes them and passes to the user network.

Information signal from the user network, transformed considering the reverse channel characteristics, via modulator, power control unit, summator, and transmitter power amplifier is supplied to transmit antenna.

However, the above device and its algorithm do not allow for implementation of the required, i.e. potential, cell capacity in case of irregular MS distribution across the cell square.

Finally, an invention has been proposed (see EP 0 817 406 "Mobile Communication System with Improved Antenna Arrangement" Int. Cl. H04B 7/26, H04Q7/36), with several embodiments of BS antenna system organization in each cell. In this technical solution, BS contains a multiplicity of transmit-receive antennas located along the cell border and have directivity characteristics oriented to the cell center.

According to the first embodiment, each of the three BS transmit-receive antennas has directivity characteristics oriented to cover 120 degree sectors of the cell square. BS transmit-receive antennas are located along the cell border with the angle interval of 120 degrees.

BS transmit-receive antennas can also be located in another way. One of them, the central BS transmit-receive antenna, has directivity characteristic covering 60 degree sector of the cell square and the other two BS transmit-receive antennas have directivity characteristics covering 120 degree sectors of the cell square and are located at the two sides of the central antenna. All BS transmit-receive antennas are located along the cell border with the angle intervals of 60 degrees.

According to the second embodiment of this antenna system, the central BS transmit-receive antenna has directivity characteristic covering 120 degree sector of the cell square and each of the two BS transmit-receive antennas at the two sides of the central BS transmit-receive antenna has directivity characteristic covering 60 degree sectors of the cell square. All BS transmit-receive antennas are located along the cell border with the angle intervals of 60 degrees.

The preferred embodiment is when BS transmit-receive antennas have directivity characteristics oriented to cover 120 degree sectors of the cell square and are located with the intervals of 60 degrees along the cell border and the undirected BS transmit-receive antenna is in the cell center.

The given invention compared to the previous technical solution in the second embodiment eases the difficulties of system frequency resource utilization that arise due to the technique of organization of the cellular communication system featuring BS sector combined circular pattern transmit-receive antennas located in the cell center.

In the mentioned patent (see EP 0 817 406 "Mobile Communication System with Improved Antenna Arrangement" Int. Cl. H04B 7/26, H04Q7/36), along with the description of embodiments of BS transmit-receive antenna organization in each cell, the issues of providing regular cell square coverage by electromagnetic radiation power are indirectly touched and certain structures of signal processing at BS and MS are considered. (see Fig. 8 –20, pp. 15-21 Patent specification).

Let us consider, for example, Fig. 20 on p. 21 of the Patent description. Fig. 20 shows the multifunction structure of BS. In the given application, the device is presented on Fig. 1.

The device of Fig.1 consists of:

BS transmit-receive antennas – $1_1 - 1_L$,

Signal diversity unit 2,

Signal combining unit 3,

Channel estimation unit 4,

Receive signal processing and transmit signal forming unit 5,

Modulator amplifier 6,

Transmission diversity control unit 7.

This device operates in the following way. A group signal, which is a sum of signals of mobile stations located within the service zone of a given BS transmit-receive antenna, arrives at each BS transmit-receive antenna $1_1 - 1_L$. Group signal energy at the input of each BS transmit-receive antenna $1_1 - 1_L$ equals the sum of signal energies from each of MS and is an average characteristic of the communication channel. Via signal diversity unit 2, these signals are supplied to channel estimation unit 4 and signal combining unit 3. Signal combining unit 3 performs an operation of diversity signal reception from each specific MS which arrives from signal diversity unit 2, in order to provide a resultant signal at the input of receive signal processing and transmit signal forming unit 5 with a maximal signal-to-noise ratio. Unit 5 demodulates the input signal and transmits it to the user network. Channel estimation unit 4 estimates the strength of the group signal in each of the channels received by BS transmit-receive antennas $1_1 - 1_L$. Quality reception at MS can be achieved by correction of the signal transmitted from BS, according to the received estimation of the communication channel state.

In particular, in TDD communication system, signals of the forward and reverse communication channels are transmitted and received at one and the same frequency. Hence, the forward and reverse channel characteristics are the same. The process of BS transmitter signal correction is as follows.

Information signal from the network is supplied via unit 5 to unit 6, where the signal for transmission in the reverse channel is generated.

Then, the signal arrives at unit 7 which transforms it according to the estimated state characteristics of communication channels that were obtained as a result of estimation in unit 4. The output signal from unit 7 arrives via unit 2 at BS transmit-receive antennas $1_1 - 1_L$.

Regular space distribution of BS transmit-receive antennas along the border only or along the border and in the cell center, as proposed in the mentioned invention, in real operation conditions leads to the following drawbacks:

- irregular distribution of BS transmit-receive antenna radiation power within a cell and decrease in connection quality between BS and MS;
- occurrence of signal shadow areas, the so called "dead zones", where no connection between BS and MS is possible;
- low quality of connection between BS and MS in the zones of depression of the electromagnetic radiation field strength, thus requiring increased electromagnetic radiation power of BS and MS transmit-receive antennas;
- impossibility to provide the required, i.e. potential, cell capacity in case of irregular MS distribution across the cell square.

The above drawbacks are clearly illustrated on Fig. 2A, 2B, and 2C. Consider them in more detail.

Fig. 2A shows 3D graphic presentation of coverage of cell square by the electromagnetic radiation power of BS transmit-receive antennas, which was obtained through computer simulation, with BS transmit-receive antennas placed along the border and in the cell center, when BS transmit-receive antennas have directivity characteristics oriented to cover 120 degree sectors of the cell square and are located along the cell border with the intervals of 60 degrees, the undirected BS transmit-receive antenna placed in the cell center.

Fig. 2B shows section projections of equal levels of electromagnetic radiation power to the horizontal plane for the three-dimensional object shown on Fig. 2A.

Fig. 2C shows section projections of equal levels of electromagnetic radiation power to the horizontal plane for the three-dimensional object shown on Fig. 2A. Conditionally, the case is demonstrated where in a cell the "dead zone" D occurs generated by a block of high buildings, constructed, for example, in a form of a "closed rectangle". On Fig. 2C this zone is shadowed. MS located in this zone is inaccessible for communication even to the nearest BS transmit-receive antennas A_1, A_4, A_5, and A_6.

Accepted denotations on Fig. 2A and Fig. 2B:

A_1 –BS transmit-receive antenna placed in the cell center,

A_2 – A_7 – BS transmit-receive antennas located along the cell border,

Accepted denotations on Fig. 2C:

A_1 – BS transmit-receive antenna placed in the cell center,

A_2 – A_7 – BS transmit-receive antennas located along the cell border,

D – "dead zone".

From Figures 2A, 2B, and 2C it can be seen that with such location of BS transmit-receive antennas, the cell square coverage by electromagnetic radiation power is irregular, due to which additional problems of signal reception in "dead zones" may arise.

Simulation of this method has shown that, in the ideal case, where the environment of radio-wave distribution is isotropic and there are no signal shadow areas, the irregularity of cell square coverage by electromagnetic radiation power becomes substantially reduced compared to the conventional transmit-receive antenna location in the cell center. Improved distribution of electromagnetic radiation power is especially evident from the vertical sections of the three-dimensional image of Fig. 2A. The vertical sections of Fig. 2A are shown on Fig. 3A, 3B, and 3C.

Consider Fig. 3A that illustrates distribution of BS transmit-receive antenna electromagnetic radiation power in the vertical section passing through BS transmit-receive antennas A_2 – A_1 - A_5.

Fig. 3A shows:

by dotted line – distribution of electromagnetic radiation power P_o in a cell, with the conventional BS transmit-receive antenna location in the cell center, where $P_{req.}$ – minimal power level of electromagnetic radiation, determined by the corresponding standards for radio communication and required to provide quality connection with MS within cell borders;

by curves a, b, c – distribution of electromagnetic radiation power in a cell from BS transmit-receive antennas, from A_2 - A_1 - A_5 respectively;

by curve d – resultant value of the electromagnetic radiation power distribution curve in a cell from BS transmit-receive antennas;

R – cell radius.

Consider Fig. 3B, which illustrates distribution of BS transmit-receive antenna electromagnetic radiation power in the vertical section passing through BS transmit-receive antennas A_2 - A_1 - A_5, in case of a “dead zone” D, generated by a block of high buildings, constructed, for example, in a form of a “closed rectangle”.

Fig. 3 B shows:

by dotted line – minimal power level of the electromagnetic radiation $P_{req.}$ determined by the corresponding standards for radio communication and required to provide quality connection with MS within cell borders;

by curve d – resultant distribution of electromagnetic radiation power in a cell from BS transmit-receive antennas, when the “dead zone” D is absent;

by curve d’ – resultant distribution of electromagnetic radiation power in a cell from BS transmit-receive antennas, in case of “dead zone” D occurence.

Consider Fig. 3C that illustrates distribution of electromagnetic radiation power of MS transmit-receive antenna in the vertical section, passing through BS transmit-receive antennas A_2 - A_1 - A_5, for the cases when MS is located in the "dead zone" D and when the "dead zone" is absent.

Fig. 3C shows:

by dotted line – minimal power level of the electromagnetic radiation $P_{req.}$, determined by the corresponding standards for radio communication and required to provide quality connection with MS within cell borders;

by curve «f» – distribution of electromagnetic radiation power of MS transmit-receive antenna, in case the "dead zone" D is absent,

by curve «e» – distribution of electromagnetic radiation power of MS transmit-receive antenna in case MS is within the "dead zone" D.

From the resultant curve d on Fig. 3A, it can be seen that, within a cell, the total power level of electromagnetic radiation of BS transmit-receive antennas located along the border and in the cell center, compared to the conventional central placing, has reduced, though substantial irregularity has remained.

From the resultant curves «d» and «d'» on Fig. 3B, it can be seen that in the "dead zone" D the total power level of electromagnetic radiation of BS transmit-receive antennas reduces sharply thus rendering the connection between BS and the user located within this zone impossible.

From the resultant curves «f» and «e» on Fig. 3C, it can be seen that the power level of electromagnetic radiation of MS transmit-receive antenna, located within the "dead zone" D, reduces sharply outside this zone thus rendering the connection between MS and nearest BS transmit-receive antennas A_1, A_5 impossible.

Therefore, with the proposed in the patent (see EP 0 817 406 "Mobile Communication System with Improved Antenna Arrangement" Int. Cl. H04B 7/26, H04Q7/36) geometry of placing BS transmit-receive antenna system, intended to provide connection between BS and MS, located within the "dead zone" D, the power of electromagnetic radiation must be substantially increased, both from BS transmit-receive antennas and MS transmit-receive antennas. This leads to irrational use of BS and MS resources and increases the noise level for other users.

Note that all the above described examples of covering the cell square by the power of electromagnetic radiation of BS transmit-receive antennas do not solve one more important problem. This problem is connected with irregular MS distribution across the cell square, which can occur both occasionally and predictably. To such zones of MS irregular distribution across the cell square belong the areas of increased MS concentration, further referred to as "IC". These are public places, for example, stadiums, exhibitions, trade fairs, shopping centers, railway stations and airports, busy motorways and so on.

Beside the geographical position of these areas in a cell, the season-day activity of mobile stations in these areas can be predicted rather accurately.

High user concentration on limited squares leads to BS overload in these cell zones, whereas the optimal mode of resource use is achieved through regular load of BS transmit-receive antennas.

Fig. 4 shows possible embodiment of MS placing across the cell square, in case in real conditions the mode of BS overload occurs.

For example, as proposed in the mentioned invention (see EP 0 817 406 "Mobile Communication System with Improved Antenna Arrangement" Int. Cl. H04B 7/26, H04Q7/36), the cell square is divided into seven service zones, where BS transmit-receive antennas A_1 - A_7, are placed, and the whole square is covered by the power of electromagnetic radiation.

Each of BS transmit-receive antennas has limited resources for MS quality service, for example, 35 MS.

Fig 4 shows that at some point of time in each of the seven service zones there is, for example, the following number of simultaneously operating MS, denotated by the corresponding numbers:

in the service zone of BS transmit-receive antenna A_1 - 35 MS,
in the service zone of BS transmit-receive antenna A_2 -10 MS,
in the service zone of BS transmit-receive antenna A_3 - 30 MS,
in the service zone of BS transmit-receive antenna A_4 - 7 MS,
in the service zone of BS transmit-receive antenna A_5 - 25 MS,
in the service zone of BS transmit-receive antenna A_6 - 20 MS,
in the service zone of BS transmit-receive antenna A_7 - 50 MS.

In the service zone of BS transmit-receive antenna A_7, 30 out of 50 MS are located on a limited predictable square of increased concentration "IC". Due to the resource deficiency, BS transmit-receive antenna A_7 can serve no more than thirty-five MS. Hence, fifteen out of fifty mobile stations will be denied service.

Therefore, such method and device should be created that would allow serving maximal number of simultaneously operating mobile stations with specified quality of information transmission and reception, i.e. would provide maximal system capacity.

According to a first aspect of the present invention, there is provided a method of radio interface organization in a cellular communication system, wherein the territory served by the communication system is divided into neighbouring cells, a base station and a multiplicity of transmit-receive antennas are placed in each cell, transmit-receive antennas are connected with the cell base station, and handoff is provided during a mobile station movement from one cell to another, the method comprising: selecting the location of base station transmit-receive antennas, orientation of antenna patterns, and their electromagnetic radiation power so that maximum uniform distribution of electromagnetic radiation power within a cell, minimal noise level for neighbouring cells, and maximum uniform distribution of mobile stations between coverage zones of different base station transmit-receive antennas are provided; providing connection between mobile stations located in the cell territory and the base station serving the given cell via those base station transmit-receive antennas in the electromagnetic radiation power coverage zone of which the corresponding mobile stations are located; and, providing handoff via those base station transmit-receive antennas in the service zone of which the corresponding mobile stations are located.

According to a second aspect of the present invention, there is provided a base station for a cellular communication system, the base station comprising *L* transmit-receive antennas, a signal diversity unit, a mobile station signal path combining unit, a channel estimation unit, a receive signal processing and transmit signal forming unit, a modulator amplifier, and a signal transmission diversity control unit, wherein the inputs of the transmit-receive antennas are mobile station device signal inputs and their outputs are connected to the corresponding first inputs of the signal diversity unit, the outputs of the signal diversity unit are connected to the first inputs of the mobile station signal path combining unit, the first outputs of which are connected to the first inputs of the receive signal processing and transmit signal forming unit, the first outputs of which are the outputs of the base station, second inputs of the receive signal processing and transmit signal forming unit are the inputs of the user signal, second outputs of receive signal processing and transmit signal forming unit are connected to the inputs of the modulator amplifier, the outputs of which are connected to the first inputs of signal transmission diversity control unit, the second inputs of which are connected to the outputs of the channel estimation unit, the outputs of the signal transmission diversity control unit are connected to the second inputs of the signal diversity unit, the outputs of which are connected to the transmit-receive antennas, a signal path search unit for searching all mobile station signal paths; and, a control processor for forming at the first outputs control signals, which assign the form and phase of the pseudo random sequence for all mobile station signal paths, at the second outputs control signals of reference signal selection for the detected mobile station signal paths, and at the third outputs control signals of reference signal selection for the detected mobile station signal paths, corrected considering time delays, wherein the first inputs of the signal path search unit are combined with first inputs of the mobile station signal path combining unit and connected to the output of the signal diversity unit, the outputs of the signal path search unit are connected to the inputs of the control processor, the first outputs of which are connected to the second inputs of the signal path search unit, the second outputs of the control processor are connected to the second inputs of the mobile station signal path combining unit, the third outputs of the control processor are connected to the first inputs of the channel estimation unit, the second inputs of which are connected to the second outputs of the mobile station signal path combining unit.

In preferred embodiments the present invention creates the method of radio interface organization and base station for a cellular communication system that improve communication system capacity and receive and transmit information quality for a larger number of simultaneously operating users.

While organizing a cellular communications system radio interface it is preferable to provide, for example, orthogonality of the signals radiated by different base station transmit-receive antennas, and soft handoff within a cell during a mobile station travel from the service zone these groups of base station transmit-receive antennas to the service zone those groups of base station transmit-receive antennas.

The groups are understood to be a set of BS transmit-receive antennas through which connection with MS is conducted within a given interval.

The preferred sequence of method operations allows for the following:

serve maximal number of simultaneously operating mobile stations with specified quality of information transmission and reception; this being achieved through the maximum regular distribution of electromagnetic radiation power within a cell and minimal noise level to neighboring cells, on the one hand, and the maximum regular distribution of mobile stations between coverage zones of different base station transmit-receive antennas, on the other one,

provide high-quality communication between mobile stations within a cell area and the base station serving this cell; this being achieved through providing communication established via those base station transmit-receive antennas, in whose electromagnetic radiation power coverage zone the corresponding mobile stations are located,

efficiently conduct handoff during a mobile station travel across cells; handoff being carried out via those base station transmit-receive antennas, in whose service zone the corresponding mobile stations are located,

provide minimal noise level to neighboring cells; this being achieved through orientation of electromagnetic radiation inwardly within a cell for BS transmit-receive antennas, located in the proximity of a cell border and selection of BS transmit-receive antenna patterns, located in "dead zones" and areas of increased MS concentration "IC", and redistribution of electromagnetic radiation power between BS transmit-receive antennas, which reduces the total power level of electromagnetic radiation to the minimum acceptable one.

Therefore, the newly proposed sequence of method operations improved communication system capacity.

BS quality signal reception from mobile stations is impossible without search for signals and their estimation. At BS, MS signal search and estimation mode should be provided. Consequently in the preferred base station equipment signal search unit and control processor, the process of MS signal reception and transmission are adjusted considering the radio channel characteristics.

It is said in the description of the mentioned patent (see EP 0 817 406 “Mobile Communication System with Improved Antenna Arrangement” Int. Cl. H04B 7/26, H04Q7/36), that BS (Fig. 1) comprises search unit and control processor. However, even if we assume that MS signal path combining unit and channel estimation unit comprise search units and control processors, it means that each of these units comprises at least one search unit and control processor, which makes the device more complex.

Moreover, the absence of links between signal combining unit 3 and channel estimation unit 4 (Fig. 1) shows that in the aforementioned device operation in the receive channel and transmit channel is not coordinated. It means that MS signal detection and channel estimation take place separately in each of these channels, which can lead to degradation of MS signal reception and transmission quality.

Introduction of signal path search unit, searching for all mobile station signal paths, and control processor which adjusts the process of MS signal reception and transmission considering the radio channel characteristics in the claimed device allows BS quality reception and transmission of MS signals.

Detailed examples of embodiment are set forth below when taken in conjunction with the drawings.

Fig. 1 is a block diagram of a known device, at which the present method is implemented.

Fig. 2A is a three-dimensional representation of cell square coverage by electromagnetic radiation power of BS transmit-receive antennas, which was obtained through computer simulation when placing BS transmit-receive antennas along the border and in the cell center, when BS transmit-receive antennas have the directivity characteristics oriented to cover 120 degree sectors of the cell area and are located with intervals of 60 degrees along the cell border, and the undirected BS transmit-receive antenna is in the cell center.

Fig. 2B is an illustration of section projections of equal levels of electromagnetic radiation power to the horizontal plane for a three-dimensional object shown on Fig. 2A.

Fig. 2C is section projections of equal levels of electromagnetic radiation power to the horizontal plane for a three-dimensional object shown on Fig. 2A; conditionally a case is demonstrated where in a cell a “dead zone” D occurs generated by a complex of tall buildings, constructed, for example, in a form of “closed rectangle”.

Fig. 3A is a distribution of BS transmit-receive antenna power of electromagnetic radiation in the vertical section passing through BS transmit-receive antennas A_2 –A_1 - A_5.

Fig. 3B is a distribution of BS transmit-receive antenna power of electromagnetic radiation in the vertical section passing through BS transmit-receive antennas A_2 - A_1 - A_5, in case of a “dead zone” D generated by a complex of tall buildings, constructed, for example, in a form of “closed rectangle”.

Fig. 3C is a distribution of MS transmit-receive antenna power of electromagnetic radiation in the vertical section passing through BS transmit-receive antennas A_2 - A_1 - A_5 for the cases when MS is in the “dead zone” D and when the “dead zone” is absent.

Fig. 4 is an example of MS placing across the cell square, as described in the known invention, leading to BS overload, when BS transmit-receive antennas are located in the center and along the border for the ideal cell form.

Fig. 5A shows an example of an ideal cell form in accordance with an embodiment of the present invention, when BS transmit-receive antennas are located along the border, in the cell center and, additionally, in the local minima of electromagnetic radiation power.

Fig. 5B shows a vertical section of BS transmit-receive antenna power of electromagnetic radiation distribution, passing through BS transmit-receive antennas A_2 – A_1 - A_5, when BS transmit-receive antennas are located along the cell border, in the cell center and, additionally to them, BS transmit-receive antennas A_8 – A_{13} are located in the local minima of electromagnetic radiation power, i.e. as shown on Fig. 5A.

Fig. 6A shows an example of an embodiment of the present invention, when BS transmit-receive antenna placing and their antenna pattern orientation are performed so that, on the one hand, maximum regular distribution of electromagnetic radiation power within a cell and minimal noise level for neighboring cells are provided, and on the other hand, maximum regular distribution of mobile stations between coverage zones of different BS transmit-receive antennas is provided considering the specific area and the current situation in a cell at some point of time.

Fig. 6B is a vertical section of BS transmit-receive antenna power of electromagnetic radiation distribution passing through BS transmit-receive antennas $A_7 - A_9 - A_2 - A_4$ of Fig. 6A. Fig. 6B clarifies the principle of overcoming A_7 transmit-receive antenna overload when switching A_9 transmit-receive antenna, serving the area of increased concentration "IC".

Fig. 7 is a block diagram of an example of a base station of a cellular communication system according to an embodiment of the present invention.

Fig. 8 is an example of a search unit used in the claimed device according to an embodiment of the present invention.

The claimed base station of the cellular communication system, shown on Fig. 7, contains *L* transmit-receive antennas $1_1 - 1_L$, unit 2 of signal diversity, unit 3 of MS signal path combining, unit 4 of channel estimation, unit 5 of receive signal processing and transmit signal forming, modulator amplifier 6, and unit 7 of signal transmission diversity control, the inputs of transmit-receive antennas $1_1 - 1_L$ are at the same time the device signal inputs and their outputs are connected to the corresponding first inputs of signal diversity unit 2, the outputs of signal diversity unit 2 are connected to the first inputs of mobile station signal path combining unit 3, the first outputs of which are connected to the first inputs of receive signal processing and transmit signal forming unit 5, the first outputs of receive signal processing and transmit signal forming unit 5 are the outputs of the device, the second inputs of which are the inputs of the user signal, second inputs of receive signal processing and transmit signal forming unit 5 are connected to the inputs of modulator amplifier 6, the outputs of which are connected to first inputs of signal transmission diversity control unit 7, the second inputs of which are connected to the outputs of channel estimation unit 4, the outputs of signal transmission diversity control unit 7 are connected to the second inputs of signal diversity unit 2, the outputs of which are connected to transmit-receive antennas $1_1 - 1_L$, according to the preferred embodiment, the device contains additionally signal path search unit 8, conducting search of all mobile station signal paths, and control processor 9, forming at the first outputs control signals, which assign the form and phase of the pseudorandom sequence for all mobile station signal paths, at the second outputs – control signals of reference signal selection for detected signal paths of mobile stations, at the third outputs - control signals of reference signal selection of detected mobile station signal paths, corrected considering time delays, the first inputs of signal path search unit 8 are combined with first inputs of mobile station signal path combining unit 3 and connected to the outputs of signal diversity unit 2, the outputs of signal path search unit 8 are connected to the inputs of control processor 9, the first inputs of which are connected to the second inputs of signal path search unit 8, second outputs of control processor 9 are connected to the second inputs of mobile station signal path combining unit 3, the third outputs of control processor 9 are connected to the first inputs of channel estimation unit 4, the second inputs of which are connected to the second outputs of mobile station signal path combining unit 3.

Fig. 7 shows an embodiment of MS signal path combining unit 3 for use in the preferred device. Unit 3 consists of L nodes of MS antenna signal path combining $10_1 - 10_L$ and node of antenna signal combining 11, the inputs of nodes $10_1 - 10_L$ of L antenna MS signal path combining form the first inputs of unit 3, second inputs of nodes $10_1 - 10_L$ of L antenna MS signal path combining form second inputs of unit 3, L outputs of nodes $10_1 - 10_L$ of L antenna MS signal path combining are connected to L inputs of antenna signal combining node 11 and form second outputs of unit 3, outputs of node 11 of antenna signal combining form first outputs of unit 3.

Fig. 8 shows an embodiment of signal path search unit 8, which contains K search channels $12_1 - 12_k$, each search channel contains correlator 13, pseudorandom sequence generator (PRSG) 14 and threshold comparison node 15, the first inputs of correlator 13 are at the same time the first inputs of the search channel, second input of correlator 13 is connected to output of PRSG 14, the input of which is the second input of the search channel, the output of correlator 13 is connected to the input of threshold comparison node 15, the output of which forms the output of the search channel. The first inputs of all search channel correlators $12_1 - 12_k$ are combined and form first inputs of search unit 8, the inputs of PRSG 14 of all search channels $12_1 - 12_k$ form the second inputs of search unit 8, the outputs of threshold comparison nodes 15 of all search channels $12_1 - 12_k$ form the outputs of search unit 8.

An example of a method of radio interface organization in a cellular communication system according to a preferred embodiment of the present invention is described below with references to the foresaid device and Fig. 5A, 5B, 6A, 6B, 7, and 8.

The territory served by the communication system is divided into neighboring cells.

BS and a multiplicity of transmit-receive antennas are placed in each cell.

Location of BS transmit-receive antennas, orientation of antenna patterns, and the power of electromagnetic radiation are selected so that, on the one hand, maximum regular distribution of electromagnetic radiation power within a cell and minimal noise level for neighboring cells are provided, and on the other hand, maximum regular distribution of mobile stations between coverage zones of different base station transmit-receive antennas is provided.

Connection of transmit-receive antennas with the cell base station is provided.

Connection between mobile stations located on the cell territory and the base station, serving the given cell via those base station transmit-receive antennas, in the electromagnetic radiation power coverage zone of which the corresponding mobile stations are located, is provided. Then, for example, signal orthogonality, radiated by different BS transmit-receive antennas, is provided.

Handoff during a mobile station travel between cells is provided via those base station transmit-receive antennas, in the service zone of which the corresponding mobile stations are located. Then soft handoff within a cell should be provided during a mobile station travel from the zone of serving some groups of base station transmit-receive antennas to the zone of serving other groups of BS transmit-receive antennas.

Consider Fig. 5A, that illustrates conditionally an exemplary organization of radio interface in the cellular communication system by the filed method for ideal conditions and ideal cell form, when BS transmit-receive antennas are located along the border, in the cell center, and in the local minima of electromagnetic radiation power, orientation of their antenna patterns is conducted so that maximum regular distribution of electromagnetic radiation power within a cell and minimal noise level for neighboring cells are provided.

Fig. 5A shows:

BS transmit-receive antenna A_1 is, for example, in the cell center,

BS transmit-receive antennas $A_2 - A_7$ are along the cell border,

BS transmit-receive antennas $A_{8'} - A_{13'}$ – are in the local minima of the electromagnetic radiation power.

The distinctive feature of this exemplary BS transmit-receive antenna location in relation to the proposed technical solution (see EP 0 817 406 "Mobile Communication System with Improved Antenna Arrangement" Int. Cl. H04B 7/26, H04Q7/36) is that BS transmit-receive antennas are located in the local minima of the electromagnetic radiation power distribution (whereas in the proposed technical solution – in the center and along the cell border). The proposed approach reduces interference between MS and between neighboring cells and improves MS connection quality, owing to signal diversity reception.

Note that the given exemplary embodiment of the claimed method, shown on Fig. 5A, can be used in practice in real conditions, both for the case of symmetrical location of BS transmit-receive antennas in local minima and for the case of unsymmetrical location of transmit-receive antennas in local minima.

Fig. 5B illustrates the advantage of the preferred embodiment compared to the prior art and shows how the distribution of BS transmit-receive antenna power of electromagnetic radiation changes, when BS transmit-receive antennas $A_8 - A_{13}$ are additionally placed in local minima of electromagnetic radiation power. The curve of BS transmit-receive antenna magnetic radiation power distribution is shown in the same vertical section as in the prior art (Fig. 3A), i.e. in the section passing through BS transmit-receive antennas $A_2 - A_1 - A_5$

On Fig. 5B it is denoted:

by dotted line – distribution of electromagnetic radiation power P_o in a cell with conventional BS transmit-receive antenna location in the cell center, where $P_{req.}$ – minimal level of electromagnetic radiation power, determined by the corresponding standards for radio communication, necessary to provide quality connection with MS within a cell;

curves a, b, c, e, f illustrate distribution of electromagnetic radiation power from BS transmit-receive antennas $A_2 - A_1 - A_5$, $A_{10} - A_{11}$, and $A_8 - A_{13}$;

curve d – resultant distribution of electromagnetic radiation power;

R – cell radius.

From the resultant curve of electromagnetic radiation power distribution d, it can be seen that the irregularity of electromagnetic radiation power distribution (compared to the prior art (see Fig. 3A) is removed by placing BS transmit-receive antennas in local minima. At the same time, further reducing the power level radiated by BS transmit-receive antennas, due to its redistribution between BS transmit-receive antennas.

Consider in detail Fig. 6A, showing an example of the claimed method preferred embodiment, when BS transmit-receive antenna location, orientation of their antenna patterns, and their power of electromagnetic radiation are selected so that, on the one hand, maximum regular distribution of electromagnetic radiation power within a cell and minimal noise level for neighboring cells are provided, and, on the other hand, maximum regular distribution of mobile stations between coverage zones of different base station transmit-receive antennas is provided. This example of BS transmit-receive antennas location considers specific geographic conditions of the territory, where the radio interface of the cellular communication system is organized and the conditions of BS transmit-receive antennas interaction with mobile stations. In addition, "dead zones" and areas of increased mobile station concentration across the cell square should be taken into account.

There is one more important fact in favor of such BS transmit-receive antenna location within a cell. In urban environment, even radiation of nondirectional antennas is anisotropic by azimuth (see William C.Y. Lee Mobile Cellular Telecommunications, Analog and Digital Systems (Second edition) New York, 1995, NY10011). The whole cell square, including shadow areas, becomes covered by electromagnetic radiation power extremely irregularly and asymmetrically. Therefore, it is impossible to achieve regular electromagnetic radiation power coverage of the cell square by any of the proposed ordered set of BS transmit-receive antennas in real conditions.

During organization of the cellular communication system radio interface the assigned area is analyzed, which is never geometrically proper in real conditions. Therefore, the cell borders will be arbitrary and will depend on the specific geographic and radio communication environment.

For example, the assigned cell square is divided into eight service zones, where BS transmit-receive antennas A_1 – A_8 providing regular distribution of electromagnetic radiation power across the cell square are located, BS transmit-receive antenna A_9 is located in the area of increased mobile station concentration (denoted “IC”), and BS transmit-receive antenna A_{10} is in the “dead zone”.

BS transmit-receive antennas are placed in the following way:

BS transmit-receive antenna A_1 – in the center or near the cell center,

BS transmit-receive antennas A_2, A_3 A_4, A_5, A_6, A_7 и A_8 – near the cell border,

BS transmit-receive antenna A_9 – in the area of increased MS concentration “IC”,

BS transmit-receive antenna A_{10} – in the “dead zone”.

By numbers in the rectangles the number of MS simultaneously served by the corresponding BS transmit-receive antennas is shown.

The shadowed area located in the service zone of transmit-receive antenna A_7 is an area of increased MS concentration “IC”.

The shadowed area located in the service zone of transmit-receive antenna A_5 is a “dead zone”.

Dotted line connecting points Z and $Z_{1,}$ denotes the route of MS travel from the zone of serving some groups of transmit-receive antennas to the zone of serving other groups of BS transmit-receive antennas, where Z – initial point, Z_1 – end point of MS travel route,

On the left, there shown a diagram of MS service zones by BS transmit-receive antennas during MS travel from point Z to point $Z_{1.}$

The shown shadowed area, located in the service zone of transmit-receive antenna A_{10}, is a “dead zone” generated, for example, due to the land lowering, i.e. ravine, or tall buildings of the type “closed rectangle”, or other reasons. Therefore, an additional BS transmit-receive antenna A_{10} is located in the “dead zone” (for example, as shown on Fig. 6A). Then the orientation, power of electromagnetic radiation, and antenna pattern of BS transmit-receive antenna A_{10} are selected considering the summed radiation power of the neighboring antennas (A_1, A_4 and A_5).

The shown shadowed area, located in the service zone of transmit-receive antenna A_7, is an area of increased MS concentration “IC”. This problem is connected with irregular MS concentration across the cell square, which can occur both occasionally and predictably during mobile station movement. To such areas of concentration belong, for example, public places, stadiums, exhibitions, trade fairs, shopping centers, railway stations, airports, busy motorways and so on. Beside the geographical position of these areas in a cell, the season-day activity of mobile stations in these areas can be predicted rather accurately

High concentration of simultaneously operating MS on limited squares leads to BS overload in these cell zones. At the same time, optimal mode of resource use is achieved through regular load of BS transmit-receive antennas.

Each of BS transmit-receive antennas A_1 – A_8 has limited resources for quality service of simultaneously operating MS, for example, 35 MS.

At some point of time, in each of the eight service zones there is, for example, the following number of MS denoted by the corresponding numbers:

in the service zone of BS transmit-receive antenna A_1 - 35 MS,
in the service zone of BS transmit-receive antenna A_2 -10 MS,
in the service zone of BS transmit-receive antenna A_3 - 30 MS,
in the service zone of BS transmit-receive antenna A_4 - 7 MS,
in the service zone of BS transmit-receive antenna A_5 - 25 MS,
in the service zone of BS transmit-receive antenna A_6 - 20 MS,
in the service zone of BS transmit-receive antenna A_7 - 50 MS, including thirty MS located on the limited predictable square of increased concentration “IC”,
in the service zone of BS transmit-receive antenna A_8 - 15 MS.

A predictable situation has occurred, when BS transmit-receive antenna A_7 can serve no more than thirty-five simultaneously operating MS. Therefore, in the zone of increased concentration “IC” BS transmit-receive antenna A_9 should be placed in advance. In the current situation this BS transmit-receive antenna A_9 will provide quality and prompt service of thirty simultaneously operating MS, located in the zone of increased concentration “IC”.

The electromagnetic radiation parameters of BS transmit-receive antenna A_9 are selected so that it serves mobile stations within the area of increased concentration “IC” only.

The algorithm of overload overcome is based on the automatical load redistribution between BS transmit-receive antenna A_7 and BS transmit-receive antenna A_9.

The electromagnetic radiation power of BS transmit-receive antenna A_9 is selected so that, in the mode of soft handoff during a mobile station travel to the zone “IC”, the service of a mobile station would switch from BS transmit-receive antenna A_7 to BS transmit-receive antenna A_9.

During radio interface organization in the cellular communication system the connection between mobile stations located on the cell territory, and base station serving the given cell should be conducted via those BS transmit-receive antennas, in the service zones of which the corresponding mobile stations are located; then, for example, orthogonality of signals radiated by different BS transmit-receive antennas should be provided.

Orthogonality of signals radiated from different BS transmit-receive antennas is required for separate processing of one and the same signal arrived from different sources of electromagnetic radiation, radiating antennas and reflecting objects.

The signal radiated from each BS transmit-receive antenna is a group signal. By the group signal we understand a sum of signals assigned for all mobile stations operating in the service zone of BS transmit-receive antennas in the given point of time, i.e. for each MS its own signal is assigned, which is orthogonal to all the rest signals of the group signal.

During reception of a mobile station signal the orthogonality of group signal identical components from different BS transmit-receive antennas can be provided through space diversity of BS transmit-receive antennas.

On the other hand, since each BS transmit-receive antenna is served by a separate base station transceiver, synchronized in time with all the rest ones, the orthogonality of signals from different BS transmit-receive antennas can be provided through additional signal coding, by means of relative time and frequency diversity of groups signals, as well as by other means.

The necessary condition for normal operation of modern cellular communication systems is provision of communication session continuity during MS travel from the one BS service zone to another BS service zone.

The procedure of a user channel (traffic channel) switch from serving by one base station to another during mobile station movement is conventionally called handoff. There are varieties of handoff, such as, for example, “hard” handoff and “soft” handoff. “Hard” handoff is characteristic of the first generation of cellular communication systems and picocellular systems, in which MS receives information, first, from one BS, then, moving to another cell, switches to another BS serving the given cell, i.e. in the reception mode MS works with one BS only (see Y.A. Gromakov. “Standards and Systems of Cellular Radio Communication”, ECO – TRENDS, Moscow, 1998, p. 68).

Modern digital radio communication systems with channel code division are characterized by “soft” handoff, when a mobile station is able to conduct parallel reception of information signal simultaneously from more than one base station, for example, in accordance with standard IS-95, (see Standard of mobile and base station compatibility for two-mode cellular wideband systems with specter extension TIA/EIA/IS-95-A, May 1995. Telecommunication Industry Association). The standard IS-95 provides for the “soft” handoff procedure, both during MS movement from one cell to another, and during movement within a cell from one cell area to another.

Consider an exemplary embodiment of the claimed method, when “soft” handoff is provided during a mobile station movement from the zone of serving some groups of BS transmit-receive antennas to the zone of serving other groups of BS transmit-receive antennas.

On Fig. 6A by the dotted line connecting points Z and Z_1, MS travel route from the zone of serving some groups of BS transmit-receive antennas to the zone of serving other groups of BS transmit-receive antennas, where Z - initial point, Z_1 – end point of MS travel route. On the left, there shown a diagram of MS service zones by BS transmit-receive antennas during MS travel from point Z to point Z_1.

In the view of electromagnetic radiation power distribution from BS transmit-receive antennas within a cell, all MS in the cell are in equal conditions. However, depending on a specific MS location in a cell, the contribution to its summed input useful signal from different BS transmit-receive antennas is inequal in power.

Assume that MS is at the initial point Z, in the service zone of one BS transmit-receive antenna A_8. As MS moves along the cell territory towards the point Z_1, it conducts connection with other BS transmit-receive antennas or groups of BS transmit-receive antennas, as shown on the diagram on Fig. 6A on the left. At the end point Z_1, which is located in the service zone of BS transmit-receive antenna A_6, MS can receive signals from BS transmit-receive antenna A_6. In this case, it should be mentioned that, MS passing through the increased concentration area "IC", is served by transmit-receive antenna A_9, located in this area.

In other words, one or more out of *L* BS transmit-receive antennas with the best conditions of signal propagation participate in a communication session with a specific MS, where *L* – total number of BS transmit-receive antennas in a cell. These transmit-receive antennas, participating in a communication session, change during MS travel. The change of a transmit-receive antenna is conducted based on the results of measuring MS levels of pilot signals, radiated by neighboring transmit-receive antennas, and analysis of the transmitted results of measurements at BS, or based on the results of analysis of signal levels received by neighboring BS transmit-receive antennas from the given MS. The decision about transmit-receive antenna change is made at BS. Thus, BS transmit-receive antennas in a cell are selected automatically and "soft" handoff is conducted within a cell.

Soft handoff during MS travel from one cell to another is conducted similarly, though the decision about transmit-receive antenna change during MS movement from one cell to another is made by BS controller.

Consider Fig. 6B, where vertical section of BS transmit-receive antenna electromagnetic radiation power distribution is shown, passing through BS transmit-receive antennas $A_7 - A_1$. Fig. 6B clarifies the principle of overcoming transmit-receive antenna A_7 overload when switching transmit-receive antenna A_9, serving the area of increased concentration “IC”.

Accepted denotations on Fig. 6B:

curve a illustrates distribution of electromagnetic radiation power of BS transmit-receive antenna A_7;

curve b - distribution of electromagnetic radiation power of BS transmit-receive antenna A_1,

curve c - distribution of electromagnetic radiation power of BS transmit-receive antenna A_4,

curve d - distribution of electromagnetic radiation power of BS transmit-receive antenna A_9,

Curves a, b, c, and d show how electromagnetic radiation power of BS transmit-receive antenna A_9, serving the area “IC”, exceeds the summed electromagnetic radiation power of BS transmit-receive antennas A_7, A_1, and A_4 in this area. Therefore, as a result of soft handoff all MS located in the area “IC” will be served by BS transmit-receive antenna A_9 only. Thus, BS transmit-receive antenna A_7 will be downloaded.

Consider the structure of signal processing at BS, according to a preferred embodiment of the present invention (Fig. 7).

BS transmit-receive antennas $1_1 - 1_L$ are placed considering specific environment (условий местности), where a cell is located, but necessarily so that, on the one hand, maximum regular distribution of electromagnetic radiation power within a cell and minimal noise level for neighboring cells are provided, and, on the other hand, maximum regular distribution of mobile stations between coverage zones of different base station transmit-receive antennas is provided, considering “dead zones” and areas of increased MS concentration “IC”.

To make it clear how the preferred embodiment is implemented, exemplary embodiments of unit 3 (Fig. 7) and unit 8 (Fig. 8) are shown.

At each BS transmit-receive antenna $1_1 - 1_L$, a group signal is supplied, which is a sum of signals from mobile stations located in the service zone of the given BS transmit-receive antenna.

The group signal at each base station transmit-receive antenna is formed by summing all signal paths of all mobile stations located in the service zone of this base station transmit-receive antenna in the given cell.

I.e. electromagnetic field of each mobile station signal path induces its power in a base station transmit-receive antenna, and the summed power corresponds to the group signal which is a sum of signals from all mobile stations that arrived at the given base station transmit-receive antenna.

The group signal of BS transmit-receive antennas $1_1 - 1_L$ is supplied to the first inputs of signal diversity unit 2.

Operation of signal diversity unit 2 can be organized in different ways. In the forward and reverse channels, unit 2 provides duplex device connection, for example, through frequency signal diversity. Unit 2 can act as a duplexer, since inputs and outputs of unit 2 are connected to the corresponding transmit-receive antennas, and base station transmit-receive antennas provide for signal reception and transmission, i.e. provide duplex communication.

The output signals from unit 2 are supplied to the first inputs of MS signal path combining unit 3 and signal path search unit 8.

Signal path search unit 8, scanning the uncertainty area by the time delay, detects a signal of each MS which can consist of several paths, in the group signals of each BS transmit-receive antenna 1_1- 1_L.

Fig. 8 shows an example, when MS signal path search unit 8 conducts scanning of uncertainty area, for example, in parallel, i.e. simultaneously in *K* search channels 12_1- 12_k. In each channel search of signal paths of all MS, forming the input group signal, are searched.

In signal path search unit 8, signal paths of specific mobile stations are isolated and their parameters - time delays - are estimated. Time delays of expected mobile station signals are estimated in signal path search unit 8, and time delays of signal paths during its schematic processing are specified in technical documentation.

In signal path search unit 8, by the control signals from control processor 9, supplied to PRSG $14_1 - 14_K$, in search channels 12_1- 12_k, signals are formed which assign the form and phase of PRS for all MS signal paths. The output signals from PRSG $14_1 - 14_K$ arrive at the second inputs of correlators 13_1- 13_k. At the first inputs of correlators 13_1- 13_k MS group signal is supplied. In search channels 12_1- 12_k, in correlators, correlations of MS input signal paths are calculated with the output signals of PRSG $14_1 - 14_K$, the results are compared in threshold comparison nodes $15_1 - 15_K$. Based on the comparison results, obtained in nodes $15_1 - 15_K$. of all search channels 12_1- 12_k, the decision about MS signal path detection.

The output signals from MS signal path search unit 8 (Fig. 7) are supplied to the first inputs of control processor 9.

Control processor 9 is made on microcomputer. It has a program, in accordance with which the algorithm of all mobile station signal path processing is performed. According to the program, control processor 9 forms reference signals for all detected MS signal paths, considering the form and phase of PRS, and supplies them to MS signal path combining unit 3 at MS signal path combining nodes $10_1 - 10_L$ via each transmit-receive antenna.

In nodes $10_1 - 10_L$, MS signal paths are combined via each BS transmit-receive antenna $1_1 - 1_L$, considering the form and phase of MS signal paths. The detected mobile station signal paths are combined by the following algorithm. For example, i-th transmit-receive antenna receives one path of the first mobile station, two signal paths of k-th mobile station, 4 paths – l-th mobile station. In i-th node of mobile station signal path combining 10_i, for each mobile station the signal paths of this mobile station are summed, considering time delays. At the output of node 10_i a summed signal for each mobile station is formed, which is in our example a sum of signal paths:

for the first mobile station – one signal path,
for k-th mobile station – summed value of two signal paths,
for l- th mobile station – summed value of four signal paths.

Similarly, in each mobile station signal path combining node signal paths are combined for each mobile station (i.e. those signal paths are combined that are detected by unit 8 at the given transmit-receive antenna).

The output signals from nodes $10_1 - 10_L$ are supplied to the second inputs of channel estimation unit 4 and antenna signal combining node 11. In unit 11 MS signal paths are combined via all BS transmit-receive antennas $1_1 - 1_L$, forming a summed output signal which is supplied to receive signal processing and transmit signal forming unit 5.

Unit 5 demodulates the input signal and transmits it to the user network.

Signal from the user network, addressed to specific MS, arrives through the second inputs of unit 5 to unit 6, where signal for transmission in reverse channel is generated.

Unit 4 estimates the signal paths of specific MS, isolated by control processor 9, and forms control command of signal transmission diversity, which is transmitted to the second inputs of signal transmission diversity control unit 7.

Unit 7, in accordance with the received from unit 4 control command of signal transmission diversity, transforms the signal, supplied from modulator amplifier 6, according to the estimated characteristics of communication channel state, i.e. in unit 7 by the signal from control processor 9 the best channels of MS signal path propagation are selected and the level of transmitted signal is corrected for MS message transmission.

The output signal from unit 7 for each MS arrives at unit 2 via selected channels of transmission to the corresponding BS transmit-receive antennas.

Thus, application of preferred embodiments of the present invention allows serving maximal number of simultaneously operating mobile stations with specified transmission and reception quality, i.e. providing maximal system capacity. This can be achieved through maximum regular distribution of electromagnetic radiation power within a cell, minimal noise level for neighboring cells, and maximum regular distribution of mobile stations between coverage zones of different base station transmit-receive antennas.

Minimal noise level for neighboring cells is achieved through orientation of electromagnetic radiation inwards the cell for BS transmit-receive antennas, located near the cell border, and selection of BS transmit-receive antenna patterns, located in “dead zones” and zones of increased MS concentration “IC”, as well as through electromagnetic radiation power redistribution between BS transmit-receive antennas, which allows reducing the total level of electromagnetic radiation power to the minimum acceptable. As a result of regular coverage by BS electromagnetic radiation power across the cell square, the required MS electromagnetic radiation power becomes reduced, which also assists in reducing mutual interference within a cell and improving the communication system capacity.

Using the claimed base station in conjunction with the claimed method of cellular communication system radio interface organization allows increasing interference stability, and thus increasing the capacity of this communication system, which is achieved through signal search at the time uncertainty interval, receive channel quality estimation for each MS and selection of the best channels for transmitting messages for MS with the corresponding correction of the transmit signal level.

The method of radio interface organization and cellular communication system base station are designed for use in CDMA telecommunication systems.

CLAIMS

1. A method of radio interface organization in a cellular communication system, wherein the territory served by the communication system is divided into neighbouring cells, a base station and a multiplicity of transmit-receive antennas are placed in each cell, transmit-receive antennas are connected with the cell base station, and handoff is provided during a mobile station movement from one cell to another, the method comprising:

selecting the location of base station transmit-receive antennas, orientation of antenna patterns, and their electromagnetic radiation power so that maximum uniform distribution of electromagnetic radiation power within a cell, minimal noise level for neighbouring cells, and maximum uniform distribution of mobile stations between coverage zones of different base station transmit-receive antennas are provided;

providing connection between mobile stations located in the cell territory and the base station serving the given cell via those base station transmit-receive antennas in the electromagnetic radiation power coverage zone of which the corresponding mobile stations are located; and,

providing handoff via those base station transmit-receive antennas in the service zone of which the corresponding mobile stations are located.

2. A method according to claim 1, comprising providing orthogonality of signals radiated by different base station transmit-receive antennas.

3. A method according to claim 1 or claim 2, comprising providing soft handoff during a mobile station movement from the zone of serving some groups of base station transmit-receive antennas to the zone of serving other groups of base station transmit-receive antennas.

4. A base station for a cellular communication system, the base station comprising *L* transmit-receive antennas, a signal diversity unit, a mobile station signal path combining unit, a channel estimation unit, a receive signal processing and transmit signal forming unit, a modulator amplifier, and a signal transmission diversity control unit,

wherein the inputs of the transmit-receive antennas are mobile station device signal inputs and their outputs are connected to the corresponding first inputs of the signal diversity unit, the outputs of the signal diversity unit are connected to the first inputs of the mobile station signal path combining unit, the first outputs of which are connected to the first inputs of the receive signal processing and transmit signal forming unit, the first outputs of which are the outputs of the base station, second inputs of the receive signal processing and transmit signal forming unit are the inputs of the user signal, second outputs of receive signal processing and transmit signal forming unit are connected to the inputs of the modulator amplifier, the outputs of which are connected to the first inputs of the signal transmission diversity control unit, the second inputs of which are connected to the outputs of the channel estimation unit, the outputs of the signal transmission diversity control unit are connected to the second inputs of the signal diversity unit, the outputs of which are connected to the transmit-receive antennas,

a signal path search unit for searching all mobile station signal paths; and,

a control processor for forming at the first outputs control signals, which assign the form and phase of the pseudo random sequence for all mobile station signal paths, at the second outputs control signals of reference signal selection for the detected mobile station signal paths, and at the third outputs control signals of reference signal selection for the detected mobile station signal paths, corrected considering time delays,

wherein the first inputs of the signal path search unit are combined with first inputs of the mobile station signal path combining unit and connected to the output of the signal diversity unit, the outputs of the signal path search unit are connected to the inputs of the control processor, the first outputs of which are connected to the second inputs of the signal path search unit, the second outputs of the control processor are connected to the second inputs of the mobile station signal path combining unit, the third outputs of the control processor are connected to the first inputs of the channel estimation unit, the second inputs of which are connected to the second outputs of the mobile station signal path combining unit.