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

(11) EP 1 193 791 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
03.04.2002 Bulletin 2002/14

(51) Int Cl.[7]: **H01Q 1/24**, H01Q 25/00

(21) Application number: **00308197.3**

(22) Date of filing: **20.09.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant: **LUCENT TECHNOLOGIES INC.**
Murray Hill, New Jersey 07974-0636 (US)

(72) Inventor: **Fischer, George, Dr.**
Nurnberg 90419 (DE)

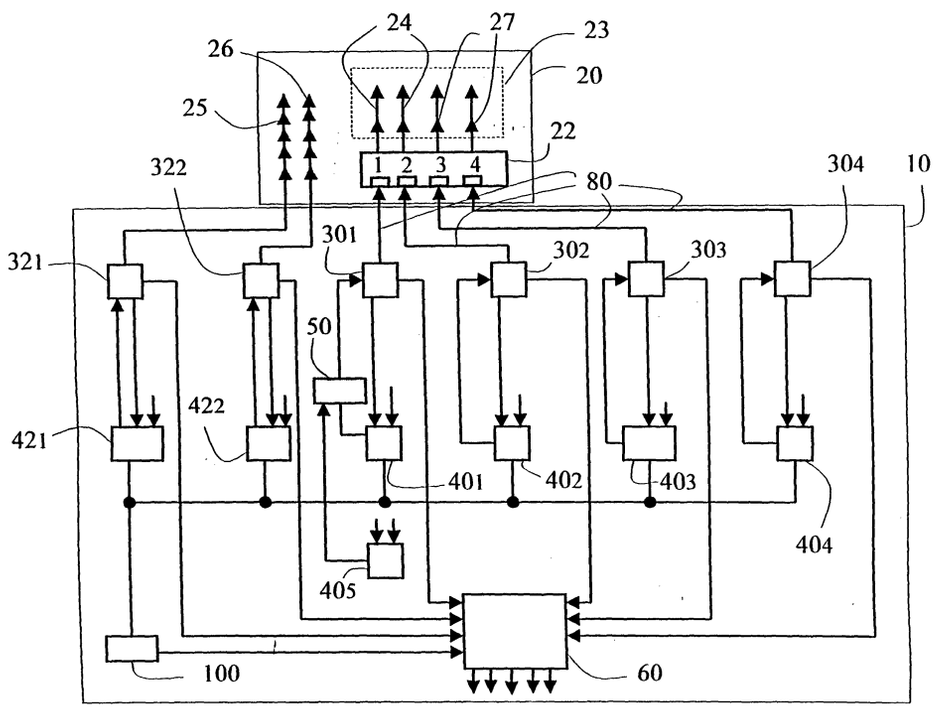
(74) Representative:
Buckley, Christopher Simon Thirsk et al
Lucent Technologies (UK) Ltd,
5 Mornington Road
Woodford Green, Essex IG8 0TU (GB)

(54) Mobile Radio System and Antenna Assembly Having Permanently Assigned Directional Characteristics

(57) In order to make it possible to increase the traffic capacity in mobile radio networks and to reduce the transmitted power, it is necessary to provide base stations for producing directional beams.

The invention is thus based on the object of providing a mobile radio system and an antenna assembly which allow an area to be illuminated to be subdivided into a plurality of area segments, using a conventional transceiver, without any major circuitry complexity, and thus economically.

The mobile radio system which is provided has at least one base station (10) which has a plurality of first transmitting/receiving devices (40_1-40_4), and an antenna device (23) associated with it. Furthermore, an RF beamformer (22) is provided, whose first ports (1 to 4) are associated with the first transmitting/receiving devices (40_1 to 40_4) and whose second ports are associated with the antenna device (23). The RF beamformer (22) interacts with the antenna device (23) in such a way that an individual antenna directional characteristic is permanently assigned to each first port (1 to 4).



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Description

Description

[0001] The invention relates to a mobile radio system having at least one base station, which has a plurality of first transmitting/receiving devices, according to the precharacterizing clause of Claim 1, and to an antenna assembly, associated with the base station, according to the precharacterizing clause of Claim 11.

[0002] The traffic capacity in a mobile radio network is rather small owing to the relatively few available frequency bands. In the GSM system, for example, only 125 frequency channels, each having eight timeslots are provided in a bandwidth of 25MHz, so that a maximum of 992 subscriber channels can be provided. One possibility for increasing the traffic capacity is to use the available frequency channels more than once on a geographic basis. The demand for "spatial frequency reuse" has, in the end, led to the development of cellular mobile radio networks. One important characteristic of cellular mobile radio networks is the signal-to-interference ratio - also referred to as the carrier-to-interference ratio (C/I), which defines the frequency repetition interval for a permanently predetermined cell size. The intensity of the interference is in this case governed essentially by co-channel interference as a function of the frequency repetition interval. Base station antennas having a directional characteristic may be used in order to reduce the intensity of the interference, and thus the frequency repetition interval. In this way, one cell can be subdivided into sectors, for example 120° sectors, with different channel groups, by which means the traffic capacity can be increased.

[0003] Apart from an increased traffic capacity, it is furthermore desirable to reduce the power transmitted by a base station antenna. This aim can be achieved by using adaptive antennas with individual antenna elements. The individual antenna elements can in this case be actuated independently of one another in terms of power and phase, in such a way that a beam can be specifically directed at a specific mobile station without also being detected by mobile stations in adjacent areas. However, the circuitry complexity to achieve this is extremely high and thus expensive since, normally, a plurality of frequency channels would have to be handled in one base station, -which would have to be supplied to the adaptive antenna via expensive, linearized multicarrier amplifiers.

[0004] The invention is thus based on the object of providing a mobile radio system and an antenna assembly which allow a plurality of directional beams without any major circuitry complexity and thus economically, and in which case, furthermore, conventional diversity receivers can be used.

[0005] The invention solves the technical problem firstly by the features of Claim 1.

[0006] According to this claim, a mobile radio system is provided having at least one base station which has a plurality of first transmitting/receiving devices, and an antenna device associated with it. Furthermore, an RF beamformer is implemented, which has a plurality of first ports, which are associated with the first transmitting/receiving devices, and has a plurality of second ports, which are associated with the antenna device. The RF beamformer interacts with the antenna device in order to permanently assign an individual antenna directional characteristic to each first port. In this way, the overall area to be illuminated by the antenna device can be subdivided into a plurality of area segments or subsectors.

[0007] Advantageous developments are the subject matter of the dependent claims.

[0008] According to one preferred embodiment, the area to be illuminated corresponds, for example, to a 120° sector, which is subdivided into four area segments of 30° each. For this situation, four first transmitting/receiving devices are provided, which are each associated with one first port of the RF beamformer. In consequence, a directional beam which illuminates one of the four area segments is associated with each first transmitting/receiving device.

[0009] The antenna device may represent an antenna array having a plurality of antenna columns, which each comprise a plurality of antenna elements. Each antenna column is connected to a separate second port of the RF beamformer, and each first port is connected to at least one first transmitting/receiving device.

[0010] An mxn-Butler matrix, having m first ports and n second ports may be used as the RF beamformer. The circuitry within the Butler matrix is chosen in such a way that, as already stated, each first port is assigned an individual antenna directional characteristic.

[0011] In order to allow diversity reception and, possibly, tracking of a mobile station, a switching matrix is provided which can be actuated and is connected between the RF beamformer and the first transmitting/receiving device. The switching matrix is used to pass a received signal from one of the area segments specifically to one or more predetermined first transmitting/receiving devices. Thanks to the switching matrix, the complexity for the wiring of the transmitting/receiving devices can also be reduced.

[0012] The control and monitoring of the transmitting/receiving devices as well as the switching matrix are carried out by a control device.

[0013] Since, in principle, a broadcast transmission control channel, also called a BCCH channel (Broadcast Channel), is transmitted over the entire cell and thus over the entire area to be illuminated in a radio cell, at least one second transmitting/receiving device is provided, which is connected to an antenna which covers the entire area to be illuminated.

[0014] For redundancy reasons, two second transmitting/receiving devices are provided in each case, which are each connected to one antenna, with the antennas being polarized orthogonally with respect to one anoth-

er.

[0015] In order to allow diversity reception in a first transmitting/receiving device, the switching matrix is likewise connected to the second transmitting/receiving device in order to pass on the received signal, which is received from the entire area to be illuminated, specifically to at least one-first transmitting/receiving device. In this case, it must be remembered that the received signal from the entire area to be illuminated and the received signal from an area segment (which signals are supplied to a corresponding first transmitting/receiving device for diversity reception) are polarized orthogonally with respect to one another. This allows so-called polarization diversity reception.

[0016] Since all the antennas are designed for both the transmission and the reception mode, each transmitting/receiving device is connected to a transmitting/receiving duplexer.

[0017] If a predetermined traffic load level is reached or exceeded in one area segment, the control device is able to switch the traffic being handled via the corresponding first transmitting/receiving device to the second transmitting/receiving device.

[0018] If the antenna device and the RF beamformer are accommodated in a housing, uncalibrated cables may be used. In consequence, the wiring between the base station and the antenna device can be considerably simplified, and costs can thus be saved.

[0019] The technical problem is likewise solved by the features of Claim 11.

[0020] According to this claim, an antenna assembly is provided for use in a mobile radio system. The antenna assembly has an RF beamformer which is equipped with a plurality of first ports, which can be associated with first transmitting/receiving devices, and with a plurality of second ports, which are associated with an antenna device. The RF beamformer interacts with the antenna device in such a way that an individual antenna directional characteristic is permanently assigned to each first port.

[0021] Advantageous developments are the subject matter of the dependent claims.

[0022] The invention will be explained in more detail in the following text with reference to an exemplary embodiment and in conjunction with a figure.

[0023] The figure shows a base station 10 which is connected via uncalibrated cables 80 to an antenna assembly 20. The base station 10 and the antenna assembly 20 are a component of a mobile radio system, for example the GSM system. The antenna assembly has an RF beamformer 22, which is in the form of a 4x4 Butler matrix, for example. The Butler matrix 22 is connected firstly to four antenna columns 24 of an antenna array 23, with each antenna column 24 having a plurality of antenna elements 25. Furthermore, the Butler matrix 22 has four ports 1, 2, 3, 4, which are each connected to a transmitting/receiving duplexer 30_1, 30_2, 30_3 or 30_4, respectively. Each transmitting/receiving duplexer is connected to a separate transmitting/receiving device, referred to for short as a transceiver in the following text, and these have the reference symbols 40_1, 40_2, 40_3 and 40_4, respectively. In this way, both the transmitting device and the receiving device of each transceiver are connected to the associated port 1, 2, 3 or 4, respectively. At this point, it should be mentioned that the Butler matrix 22 is connected in such a way that an individual directional characteristic is assigned to each port 1, 2, 3 and 4 via the antenna columns 24 of the antenna array 23. By way of example, the antenna array 23 is intended to illuminate an area of 120° divided into four subsectors of 30° each. To this end, the Butler matrix 22 in conjunction with the antenna array 23 produces four differently aligned beams at an angle of 30° in each case, to be precise depending on which of the ports 1, 2, 3, 4 a transmission power is applied to. Instead of associating only one transceiver with each port 1, 2, 3, 4, further transceivers 40_s may be connected to the respective port via a transmission combination circuit 50. Only the one transmission combination circuit 50 and the further transceiver 40_s are shown, merely in order to simplify the illustration. It should be noted at this point that the antenna columns 24 have an inclined linear polarization.

[0024] One essential aspect of the invention is to permanently assign an individual antenna directional characteristic to each transceiver 40_1, 40_2, 40_3 and 40_4, so that each transceiver can produce a directional beam with the aid of the Butler matrix 22 and the antenna array 23. In this way, it is possible to handle communication between one mobile station and one of the four transceivers in the base station 10 specifically.

[0025] However, since BCCH channels have to be transmitted to all the mobile stations in the area of the cell to be illuminated, two further antennas 25 and 26 with mutually orthogonal polarizations are provided, which can illuminate the entire area. The two antennas 25 and 26 are respectively connected via a transmitting/receiving duplexer 32_1 and 32_2 to a transceiver 42_1 or 42_2, respectively.

[0026] A switching matrix 60, which can be actuated by a control device 100, is provided in order to allow, for example, a mobile station to move from one area sector to another area sector, or to allow diversity reception for the transceivers 40_1 to 40_4. The switching matrix 60 is, for example, connected on the input side to the transmitting/receiving duplexers 30_1 to 30_4 and 32_1. At this point, it should be mentioned that the antenna columns 24 and the antenna 25 are polarized orthogonally with respect to one another so that polarization diversity reception is possible in the transceivers 40_1 to 40_4. On the output side, the switching matrix 60 can in each case be connected to a second receiving input of the transceivers 40_1 to 40_4. To simplify the illustration, the individual connections which lead from the switching matrix 60 to the transceivers are not shown.

[0027] The switching matrix 60 can be connected, for example, in such a way that not only the port 1 but, se-

lectively, the port 2, 4 or the signal received via the antenna 25 can be applied to the transceiver 40_1. Apart from the port 2, the port 1, the port 3 or the received signal from the antenna 25 can selectively be applied to the transceiver 40_2 with the aid of the switching matrix 60. Apart from the port 3, the port 3, the port 1 or the signal received via the antenna 25 is applied selectively to the transceiver 40_3 with the aid of the controllable switching matrix 60. In a similar way, the transceiver 40_4 and further additional transceivers, which are not shown, can be connected to one another via a second switching matrix, which is not shown.

[0028] In order to ensure diversity reception, the appropriate transceiver 40_1 to 40_4 is connected on the input side firstly to the port associated with it and secondly to the signal received from the antenna 25, via the switching matrix 60. Thus, with this so-called polarization diversity reception, a signal is received from the area segment associated with the respective transceiver together with the signal received from the entire area to be illuminated. If, on the other hand, it is intended to track the movement of a mobile station from the area segment 2 associated with the port 2 to the area segment 3 associated with the port 3, for example, then the received signal from the corresponding area segment can be supplied via the port 2 to the transceiver 40_2, and the received signal from the corresponding area segment can be supplied via the port 3, by means of the switching matrix 60, to the transceiver 40_2.

[0029] If, during operation, the control device 100 finds that, for example, the area segment associated with the port 3, and thus the transceiver 40_3, is overloaded due to an excessively high volume of traffic, the control device 100 can ensure that the traffic handled via the transceiver 40_3 is transferred to the transceiver 42_2. The traffic channels can be handed over to the two transceivers 42_1 and 42_2 since, fundamentally, each transceiver has an associated traffic channel, and thus eight timeslots. Since, however, only three timeslots are required for transmission of BCCH channels, thirteen further timeslots are available overall for transmission of data via the transceivers 42_1 and 42_2.

Claims

1. Mobile radio system having
at least one base station (10) which has a plurality of first transmitting/receiving devices (40_1-40_4), and an antenna device (23) associated with it,
characterized by
an RF beamformer (22) having a plurality of first ports (1-4) which are associated with the first transmitting/receiving devices (40_1-40_4), and having a plurality of second ports which are associated with the antenna device (23), in which case the RF beamformer (22) permanently assigns an individual antenna directional characteristic to each first port (1-4) by interaction with the antenna device (23).

2. Mobile radio system according to Claim 1,
characterized in that
each individual antenna directional characteristic corresponds to a predetermined area segment of an area to be illuminated.

3. Mobile radio system according to Claim 1 or 2,
characterized in that
the antenna device (23) comprises a plurality of antenna columns (24) having a plurality of antenna elements (25), in which case each antenna column (24) is connected to a separate second port of the RF beamformer (22), and each first port (1-4) is connected to at least one first transmitting/receiving device (40_1-40_4).

4. Mobile radio system according to Claim 1, 2 or 3,
characterized in that
the RF beamformer (22) is an mxn-Butler matrix.

5. Mobile radio system according to one of Claims 2 to 4,
characterized by at least one switching matrix (60) which can be actuated and is connected between the RF beamformer (22) and the first transmitting/receiving devices (40_1-40_4).

6. Mobile radio system according to one of Claims 1 to 5, **characterized in that** each first port (1-4) is connected via a transmitting/receiving duplexer (30_1-30_4) to the corresponding first transmitting/receiving device or devices (40_1-40_4).

7. Mobile radio system according to one of Claims 1 to 6,
characterized by at least one second transmitting/receiving device (42_1-42_2), which is connected to an antenna (25, 26) which covers the entire area to be illuminated, in which case a received signal from the entire area to be illuminated can be supplied to the second transmitting/receiving device (42_1-42_2) and/or to the switching matrix (60) which can be actuated and can specifically pass on the received signal to at least one first transmitting/receiving device (40_1-40_4).

8. Mobile radio system according to one of Claims 1 to 7,
characterized by
a control device (100) for controlling and monitoring the transmitting/receiving devices (40_1-40_4) and the switching matrix (60).

9. Mobile radio system according to Claim 8,
characterized in that
the control device (100) is designed for switching

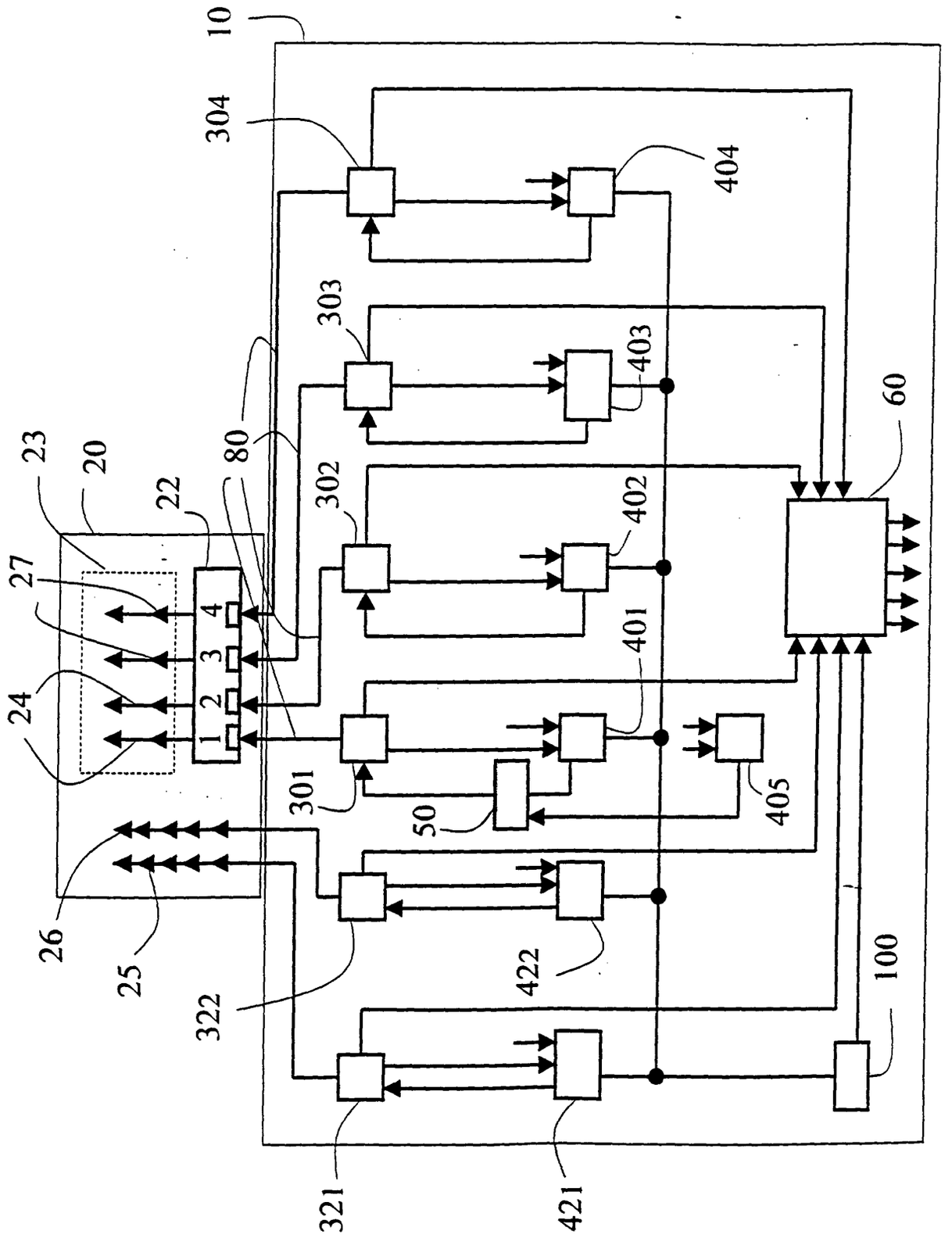
the traffic which is handled via one or more of the first transmitting/receiving devices (40_1-40_4) to the second transmitting/receiving device (42_1-42_2).

10. Mobile radio system according to one of Claims 1 to 9,
characterized in that
the antenna device (23), the RF beamformer (22) and/or the antenna (25,26) are accommodated in a housing.

11. Antenna assembly for use in a mobile radio system in particular according to one of Claims 1 to 10,
characterized by
an antenna device (23) and
an RF beamformer (22) having a plurality of first ports (1-4) which can be associated with transmitting/receiving devices (40_1-40_4), and having a plurality of second ports which are associated with the antenna device (23), in which case the RF beamformer (22) permanently assigns an individual antenna directional characteristic to each first port (1-4) by interaction with the antenna device (23).

12. Antenna assembly according to Claim 11,
characterized in that
the antenna device (23) comprises a plurality of antenna columns (24) having a plurality of antenna elements (25), in which case each antenna column (24) is connected to a separate second port of the RF beamformer (22), and each first port (1-4) can be connected to at least one first transmitting/receiving device (40_1-40_4) of a base station (10).

13. Antenna assembly according to Claim 11 or 12,
characterized in that
the RF beamformer (22) is an mxn-Butler matrix.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EUROPEAN SEARCH REPORT

Application Number
EP 00 30 8197

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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X	WO 98 50981 A (ERICSSON TELEFON AB L M) 12 November 1998 (1998-11-12) * page 5, line 13 - line 16 * * page 7, line 5 - line 11 * * page 12, paragraphs 2,4 * * page 14, paragraphs 3,4 * * page 15, paragraphs 1-3; claims 1-7; figures 1,2,6 * ---	1-4,6, 10-13	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 January 2001	Moumen, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 30 8197

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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