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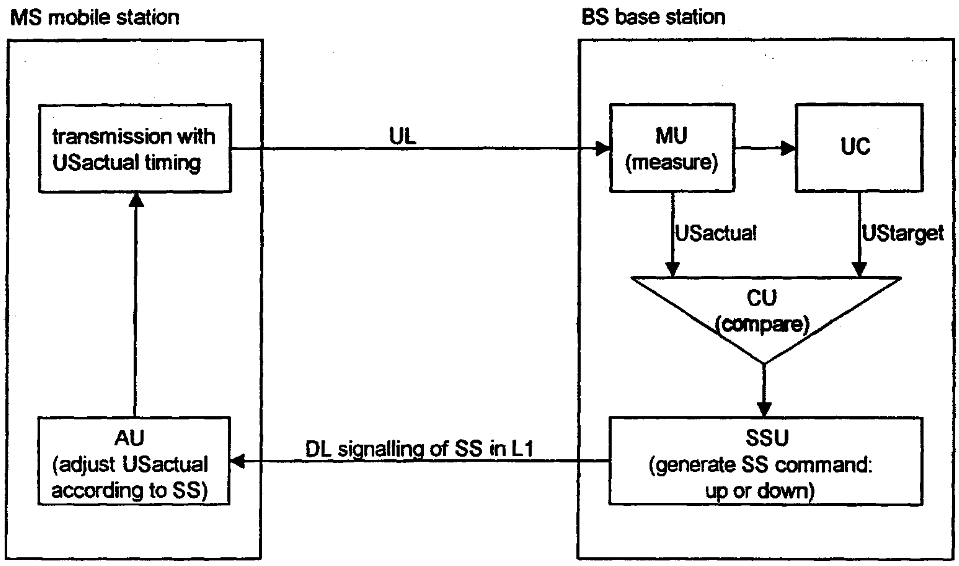
(54) Title: METHOD AND SYSTEM FOR MAINTAINING UPLINK SYNCHRONIZATION IN CDMA BASED MOBILE COMMUNICATIONS SYSTEMS



(57) Abstract: A method and system for maintaining uplink synchronization in CDMA based mobile communication system with high accuracy and fast update frequency, said mobile communication system comprising a base station, at least one mobile station, said method comprising the steps of: receiving signals transmitted by one of said mobile stations; measuring timing of the transmitted signals from the mobile station and obtaining US_{Actual} value currently used in the mobile station; calculating a US_{Target} value based on the measurement; comparing US_{Actual} and US_{Target} to generate a SS command for increasing or decreasing said US_{Actual}; signaling said synchronization shift (SS) command in downlink to said mobile station to increase or decrease said US_{Actual}.

WO 01/24411 A1

Description

METHOD AND SYSTEM FOR MAINTAINING UPLINK SYNCHRONIZATION IN CDMA BASED MOBILE COMMUNICATIONS SYSTEMS

Field of the invention

The present invention relates to CDMA technology, in particular, a method and system for maintenance of UL synchronization in CDMA based mobile communication systems.

Technical background

For most CDMA systems, the uplink channels are asynchronous. That means the signals of the users arrive at the serving Node B (the Base Station) at different time. So the asynchronous spreading codes used by different users (for example PN (pseudo noise) sequence) will interfere each other. That interference is known as Multi-Access-Interference. Since CDMA is an interference-limited system, any additional interference will result in capacity reduction. Uplink synchronization or so-called synchronous CDMA system keeps all user signals reaching the base station at the same time. It will greatly reduce Multi-Access-Interference. Thus uplink synchronization (US) will lead to higher capacity and simplify the demodulator in Node B at the base station side.

Synchronization is more difficult to realize in mobile communications system because of the multi-path and shadow fading characteristic of mobile channel. Since the channel characteristic varies in time frequently and the accuracy for uplink (UL) synchronization must be high, the update frequency of the mobile's transmission TX timing must be fast. The problem is how to find an effective way to realize uplink synchronization and keep the system spending acceptable. The realization of UL synchronization can be divided into two parts: UL synchronization establishment and UL synchronization maintenance. In the invention a simple and effective method to maintain the uplink synchronization is described.

From the layer 1 point of view, the UL synchronization is equivalent to a very high precise timing advance. In current system, there exist a scheme for timing advance. Fig. 1 illustrates a schematic diagram of the timing advance scheme. As shown in Fig. 1, there is a propagation delay when the BS receives the UL transmission signal. Therefore, a timing advance is provided to the burst during UL transmission at the mobile station (MS) site, so that the burst received at the BS can be just in time.

However, in the existing timing advance scheme, the timing advance information is transmitted from layer 3. Since the accuracy for UL synchronization is higher and the update frequency is faster than timing advance, the timing advance scheme cannot meet the requirement of UL synchronization. In current mobile communications system, there is no solution for UL synchronization. Hence before the invention, the problem is open.

Summary of the invention

One object of the invention is to provide a method and system for maintenance of UL synchronization in CDMA based mobile communication systems with high accuracy and fast update frequency, thereby reducing multi-access-interference effectively, achieving higher capacity of the CDMA system.

A further object of the invention is to provide a communication system utilizing the above method, and the base station and mobile station thereof.

The present invention provides a method for maintaining uplink synchronization in mobile communication system, said mobile communication system comprising a base station, at least one mobile station, said method comprising the steps of : receiving signals transmitted by one of said mobile station; measuring timing of the transmitted signals from the mobile station and obtaining an actual uplink synchronization (US_{Actual}) value currently used in the mobile station; calculating a target uplink synchronization (US_{Target}) value based on the measurement; comparing US_{Actual} and US_{Target} to generate a synchronization shift (SS) command for increasing or decreasing said US_{Actual}; signaling said synchronization shift (SS) command in downlink to said mobile station to increase or decrease said US_{Actual}..

The present invention further provides a system for maintaining uplink synchronization in mobile communication system, said mobile communication system comprising a base station, at least one mobile station, said system comprising: receiving means for receiving signals transmitted by one of said mobile station; measuring means for measuring timing of the transmitted signals from the mobile station and obtaining US_{Actual} value currently used in the mobile station; calculating means for calculating a US_{Target} value based on the measurement; comparing means for comparing US_{Actual} and US_{Target} to generate a SS command for increasing or decreasing said US_{Actual}; signaling means for signaling said synchronization shift (SS) command in downlink to said mobile station to increase or decrease said US_{Actual}..

The present invention further provides a mobile communication system, comprising: a base station; at least one mobile station; wherein said base station comprises: receiving means for receiving signals transmitted by one of said mobile station; measuring means for measuring timing of the transmitted signals from the mobile station and obtaining US_{Actual} value currently used in the mobile station; calculating means for calculating a US_{Target} value based on the measurement; comparing means for comparing US_{Actual} and US_{Target} to generate a SS command for increasing or decreasing said US_{Actual}; signaling means for signaling said synchronization shift (SS) command in downlink to said mobile station to increase or decrease said US_{Actual} , and
wherein said mobile station comprises: adjusting means for increase or decrease said US_{Actual} according to said synchronization shift command, as well as the base station and mobile station used therein.

Brief description of the drawings

Fig. 1 illustrates a schematic diagram of the timing advance scheme at L3 level.
Fig. 2 illustrates a schematic diagram of the CDMA system according to one embodiment of the present invention.
Fig. 3 illustrates a schematic diagram for examples for calculating US_{Target} according to the invention.
Fig. 4 shows an example of the position of the SS(synchronization shift) command in a traffic burst.
Fig. 5 shows another example of the position of the SS(synchronization shift) command in a traffic burst when TFCI is transmitted.

Detailed description of the preferred embodiments of the invention

Fig. 2 illustrates a schematic diagram of the CDMA system according to one embodiment of the present invention. As shown in Fig.2, the base station receives the signals transmitted in uplink from the mobile station. The base station includes a measurement unit MU for measuring the timing of the received signals, and obtaining a US_{Actual} , which is a US value (equivalent to a timing advance) currently used by the mobile station; a uplink synchronization control unit UC for calculating a US_{Target} , which is defined as exactly that value that would be optimal for UL synchronization; a compare unit CU for comparing the US_{Actual} with the US_{Target} ; and a SS command generating unit SSU for generating a SS command according to the comparison result. The SS command is downlink signaled in Layer 1 L1 to the mobile station MS to adjust, increase or decrease the US_{Actual} value used in the MS. Needless to say, the base station also includes a receiving means (not shown) for receiving signals transmitted from the MS; and a signaling means (not shown) for transmitting signals having the SS commands in downlink to the MS. They can be a known receiver or transmitter, thereby the details thereof are not described in this application. The transmission unit in the MS transmits signals with the US_{Actual} timing, and the adjustment unit AU in the MS adjusts the US_{Actual} value according to the SS commands.

According to the embodiment of the present invention, a new L1 (layer 1) signaling SS (synchronization shift) is used to maintain UL synchronization, The SS commands are transmitted in the downlink of the physical layer.

As shown in Fig. 2, the measurement unit in the serving node B or base station continuously measures the timing of a transmission from the user equipment, i.e., the mobile station MS. Then, based on these measurements, the UL synchronization Control UC unit calculates the US_{Target}. The US_{Target} is defined as exactly that value that would be optimal for UL synchronization. The US value that is currently used by the system is defined as US_{Actual} .

The SS command is generated by the relationship between US_{Actual} and US_{Target} and is used to increase or decrease US_{Actual} . Hence the SS is up- or down-command and does not signal the US_{Target} itself. The US_{Actual} is changed in steps according to SS commands and one (single stepsize) or more (multiple stepsizes) predefined stepsize. The smallest stepsize is equivalent to the necessary accuracy of UL synchronization.

The process of the UL synchronization control according to an embodiment of the present invention may includes the following steps: Synchronization Control unit UC calculates a US Target; SS command is generated by comparing of US_{Actual} and US_{Target} , wherein SS is an up- or down-command; SS command is used by the MS to increase or decrease US_{Actual} in predefined step(s), which are known in advance and/or are encoded in the SS command; SS command is signaled in layer 1 L1 (SS field in Burst) to achieve the high update frequency of US.

One embodiment of the UL synchronization in the UTRA-TDD system or in the TD-SCDMA system according to the present invention will be described below.

The required accuracy for UL synchronization is, for example, ±1/8chips. The serving node B at the BS side continuously measures the timing of a transmission from the MS, obtains the US_{Actual}, and calculates a US_{Target}. Based on the comparison of the US_{Actual} and the US_{Target} , SS commands are generated and signaled in DL. The US_{Actual} used in MS is changed in steps according to SS commands, and changed one (single stepsize) or more (multiple stepsizes) predefined stepsizes.

Fig. 3 illustrates a schematic diagram for explaining the calculation of the US_{Target} in the UL synchronization control unit UC according to the invention.

The UC has the purpose of calculating the US_{target}. Because of the multipath effect and the time variance of the channel, a perfect UL synchronization cannot be established. Therefore the US_{target} has the purpose to find that timing for UL transmission, where the performance of US is optimal. Two basic methods are possible, one is slow UC, the other is fast UC.

As shown in Fig. 3, from the bottom to the top, there are three bursts (for exemplary purpose) in time sequence transmitted from the MS are received at the BS. For each of the burst, the BS receives corresponding taps of impulse response IR. Since the MS is moving and is in a time variant environment, the IR at the BS side is varied in time and in power, as shown in Fig. 3.

For slow UC, which means the statistics of the IR is used to calculate an optimal value, the US_{target}, the US_{target} is equivalent to the propagation delay plus the delay of that tap in the IR, that has the highest power in average. This method additionally includes the average characteristics of the mobile station's IR. Therefore the UC must know the statistics of the IR.

For fast UC, the US_{target} is equivalent to the propagation plus the delay of that tap in the IR, that has actually the highest power. This method should provide the best performance of US, however the US_{target} will rapidly change, which causes more frequent signaling of SS commands in the DL.

With either slow UC or fast UC, the value of US_{target} can be obtained.

The smallest stepsize is equivalent to the necessary accuracy, for example, 1/8 Chips. The stepsize can be a fixed value pre-set in the MS. It is also possible for the BS to broadcast the stepsize to the respective mobile stations, and each of the MSs use the received stepsize to increase or decrease its US_{Actual} value. The SS commands are transmitted in the physical layer, i.e., L1-signaling.

For example, the algorithm for a single stepsize is
If $US_{Actual} > US_{Target}$, then the SS=0;
If $US_{Actual} < US_{Target}$, then the SS=1;

In one embodiment of the invention, the SS information is one bit. More bits can be used for multiple stepsizes or error protection. Since SS commands are signaled in L1, they need a special field in the burst. The SS field is only added in DL timeslots because the transmission of SS is only needed in DL.

Fig. 4 and Fig.5 shows two examples of the position of the synchronization shift command SS in a traffic burst, according to the present invention.

As shown in Fig. 4, in this example, one symbol (two bits) for SS field is reserved. The SS field is placed around the midamble in order to achieve effective protection in time-variant environments. The reason for placing the SS command near the midamble is that the above measurement is made at the midamble, so that the adjustment of the US value at the MS can be more based on the real US status and more efficiently. The SS information is transmitted every frame in DL physical channel. Fig.4 shows the position of SS in traffic DL burst for UTRA (UMTS(Universal Mobile Telecommunication System) terrestrial radio access) -TDD(Time Division Duplex) system.

If TFCI (Transport Format Combination Indicator) is transmitted, The SS is transmitted directly adjacent to the TFCI. Fig. 5 shows the position of SS in traffic DL burst when TFCI is transmitted.

The adjustment of the current timing advance is changed according to the following rule:

$$US_{Actual,new} = \begin{cases} US_{Actual,old} + \Delta_{US} & \text{If } SS=1 \\ US_{Actual,old} - \Delta_{US} & \text{If } SS=0 \end{cases}$$

Where, Δ_{US} is single stepsize for the modification of US. In this implementation, Δ_{US} is equal to 1/8 chips and it is predefined in the system.

From the above description to the preferred embodiments of the present invention, it is apparent that the present invention provide an effective method to maintain the uplink synchronization in CDMA based mobile communication systems with high accuracy and fast update frequency. And consequently, it will greatly reduce multi-access-interference, and lead to higher capacity of the CDMA system as well as simplify the demodulator at the base station side.

The forgoing has described the preferred embodiments of the present invention. It is contemplated that changes and modifications can be made by one of ordinary skill in the art, based on the disclosure of the present invention, without departing from the scope of the invention.

What is claimed is:

1. A method for maintaining uplink synchronization in a mobile communication system, said mobile communication system comprising a base station, and at least one mobile station, said method comprising the steps of :
receiving signals transmitted by one of said mobile station;
measuring timing of the transmitted signals from the mobile station and obtaining an actual uplink synchronization (US_{Actual}) value currently used in the mobile station;
calculating a target uplink synchronization (US_{Target}) value based on said measurement;
comparing said actual uplink synchronization value (US_{Actual}) and said target uplink synchronization value (US_{Target}) to generate a synchronization shift (SS) command for increasing or decreasing said actual uplink synchronization value (US_{Actual});
signaling said synchronization shift (SS) command in downlink to said mobile station to increase or decrease said actual uplink synchronization (US_{Actual}) value.

2. The method according to claim 1, wherein said synchronization shift (SS) command is signaled in a predetermined field in burst in layer 1.

3. The method according to claim 2, wherein said predetermined field is placed around the midamble in the burst.

4. The method according to claim 3, wherein said measurement is made at the midamble.

5. The method according to claim 1, wherein said synchronization shift (SS) command is transmitted every frame in physical channel.

6. The method according to claim 1, wherein the channel statistics is used to calculate said target uplink synchronization (US_{Target}) value in said calculating step.

7. The method according to claim 1, wherein a tap in impulse response having actually the highest power is used to determine said target uplink synchronization (US_{Target}) value in said calculating step.

8. The method according to claim 1, wherein said mobile station increases or decreases the actual uplink synchronization (US_{Actual}) value according to said synchronization shift (SS) command in a predetermined stepsize or stepsizes.

9. The method according to claim 8, wherein said stepsize is a fixed value preset in said mobile station.

10. The method according to claim 8, wherein said mobile station receives the stepsize broadcasted from said base station.

11. A system for maintaining uplink synchronization in a mobile communication system, said mobile communication system comprising a base station, and at least one mobile station, said system comprising:
receiving means for receiving signals transmitted by one of said mobile station;
measuring means for measuring timing of the transmitted signals from the mobile station and obtaining an actual uplink synchronization (US_{Actual}) value currently used in the mobile station;

calculating means for calculating a target uplink synchronization (US_{Target}) value based on the measurement;
comparing means for comparing said actual uplink synchronization (US_{Actual}) value and said target uplink synchronization (US_{Target}) value to generate a synchronization shift (SS) command for increasing or decreasing said actual uplink synchronization (US_{Actual}) value;
signaling means for signaling said synchronization shift (SS) command in downlink to said mobile station to increase or decrease said actual uplink synchronization (US_{Actual}) value.

12. The system according to claim 11, wherein said synchronization shift (SS) command is signaled in a predetermined field in burst in layer 1.

13. The system according to claim 12, wherein said predetermined field is placed around the midamble in the burst.

14. The system according to claim 13, wherein said measurement is made at the midamble.

15. The system according to claim 11, wherein said synchronization shift (SS) command is transmitted every frame in physical channel.

16. The system according to claim 11, wherein the channel statistics is used to calculate said target uplink synchronization (US_{Target}) value in said calculating step.

17. The system according to claim 11, wherein a tap in impulse response having actually the highest power is used to determine said target uplink synchronization (US_{Target}) value in said calculating step.

18. The system according to claim 11, wherein said mobile station includes an adjusting means for increasing or decreasing the actual uplink synchronization (US_{Actual}) value according to said synchronization shift (SS) command in a predetermined stepsize or stepsizes.

19. The system according to claim 18, wherein said stepsize is a fixed value preset in said mobile station.

20. The system according to claim 19, wherein said mobile station receives the stepsize broadcasted from said base station.

21. A mobile communication system, comprising:
a base station;
at least one mobile station;
wherein said base station comprises:
receiving means for receiving signals transmitted by one of said mobile station;
measuring means for measuring timing of the transmitted signals from the mobile station and obtaining an actual uplink synchronization (US_{Actual}) currently used in the mobile station;
calculating means for calculating a target uplink synchronization (US_{Target}) value based on the measurement;
comparing means for comparing said actual uplink synchronization (US_{Actual}) value and said target uplink synchronization (US_{Target}) to generate a synchronization shift (SS) command for increasing or decreasing said actual uplink synchronization (US_{Actual}) value;

signaling means for signaling said synchronization shift (SS) command in downlink to said mobile station to increase or decrease said actual uplink synchronization (US_{Actual}) value, and wherein said mobile station comprises:
adjusting means for increase or decrease said actual uplink synchronization (US_{Actual}) value according to said synchronization shift command (SS).

22. The mobile communication system according to claim 21, wherein said synchronization shift (SS) command is signaled in a predetermined field in burst in layer 1.

23. The mobile communication system according to claim 22, wherein said predetermined field is placed around the midamble in the burst.

24. The mobile communication system according to claim 23, wherein said measurement is made at the midamble.

25. The based mobile communication system according to claim 21, wherein said synchronization shift (SS) command is transmitted every frame in physical channel.

26. The mobile communication system according to claim 21, wherein the channel statistics is used to calculate said target uplink synchronization (US_{Target}) value in said calculating step.

27. The mobile communication system according to claim 21, wherein a tap in impulse response having actually the highest power is used to determine said target uplink synchronization (US_{Target}) value in said calculating step.

28. The mobile communication system according to claim 21, wherein said mobile station includes an adjusting means for increasing or decreasing said actual uplink synchronization (US_{Actual}) value according to said synchronization shift (SS) command in a predetermined stepsize or stepsizes.

29. The mobile communication system according to claim 28, wherein said stepsize is a fixed value preset in said mobile station.

30. The mobile communication system according to claim 29, wherein said mobile station receives the stepsize broadcasted from said base station.

31. The base station system used in the mobile communication system according to claims 21-30.

32. The mobile station system used in the in the mobile communication system according to claims 21-30.

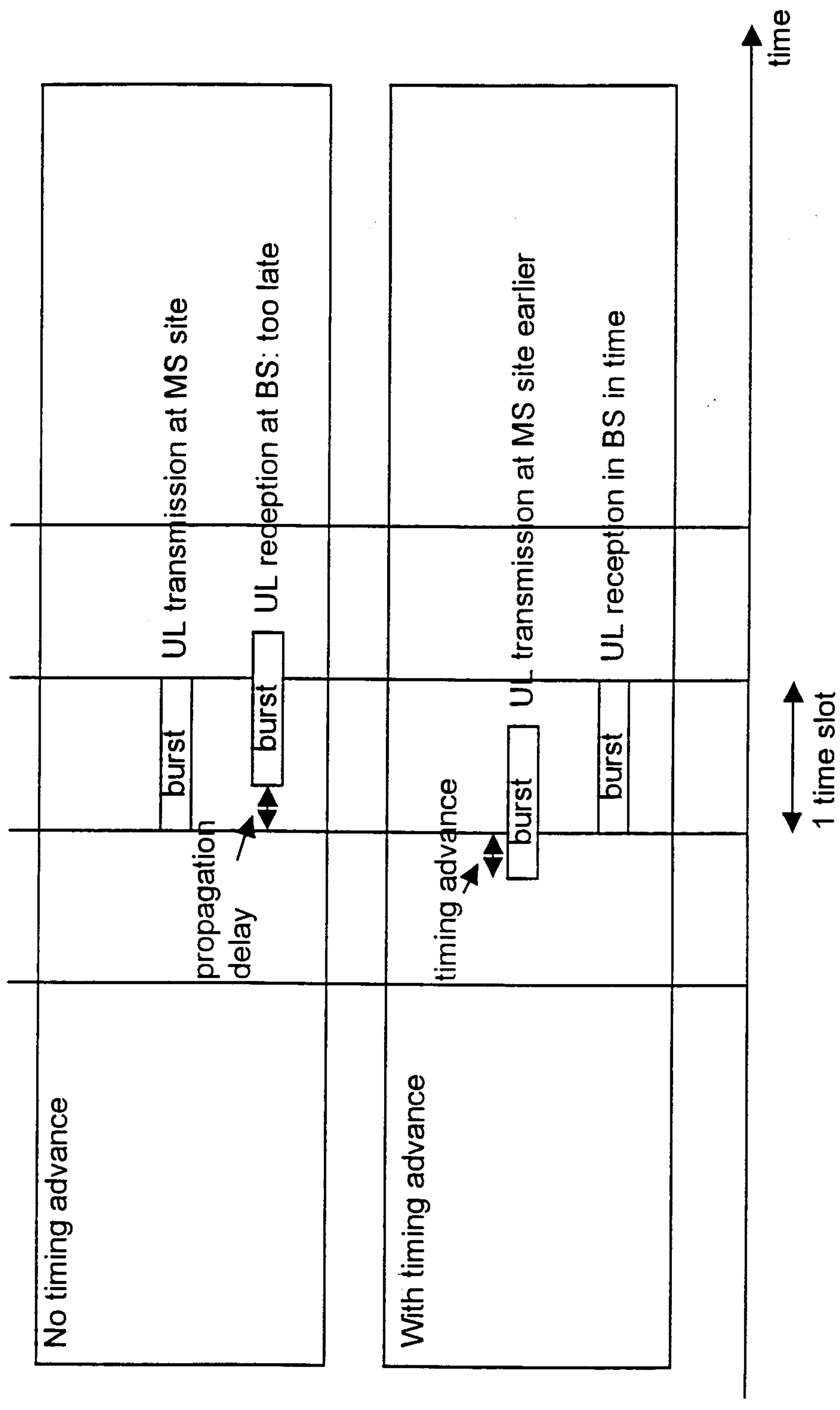

No timing advance
UL transmission at MS site
UL reception at BS: too late
burst
burst
propagation delay
With timing advance
UL transmission at MS site earlier
UL reception in BS in time
burst
burst
timing advance
1 time slot
time

Fig. 1

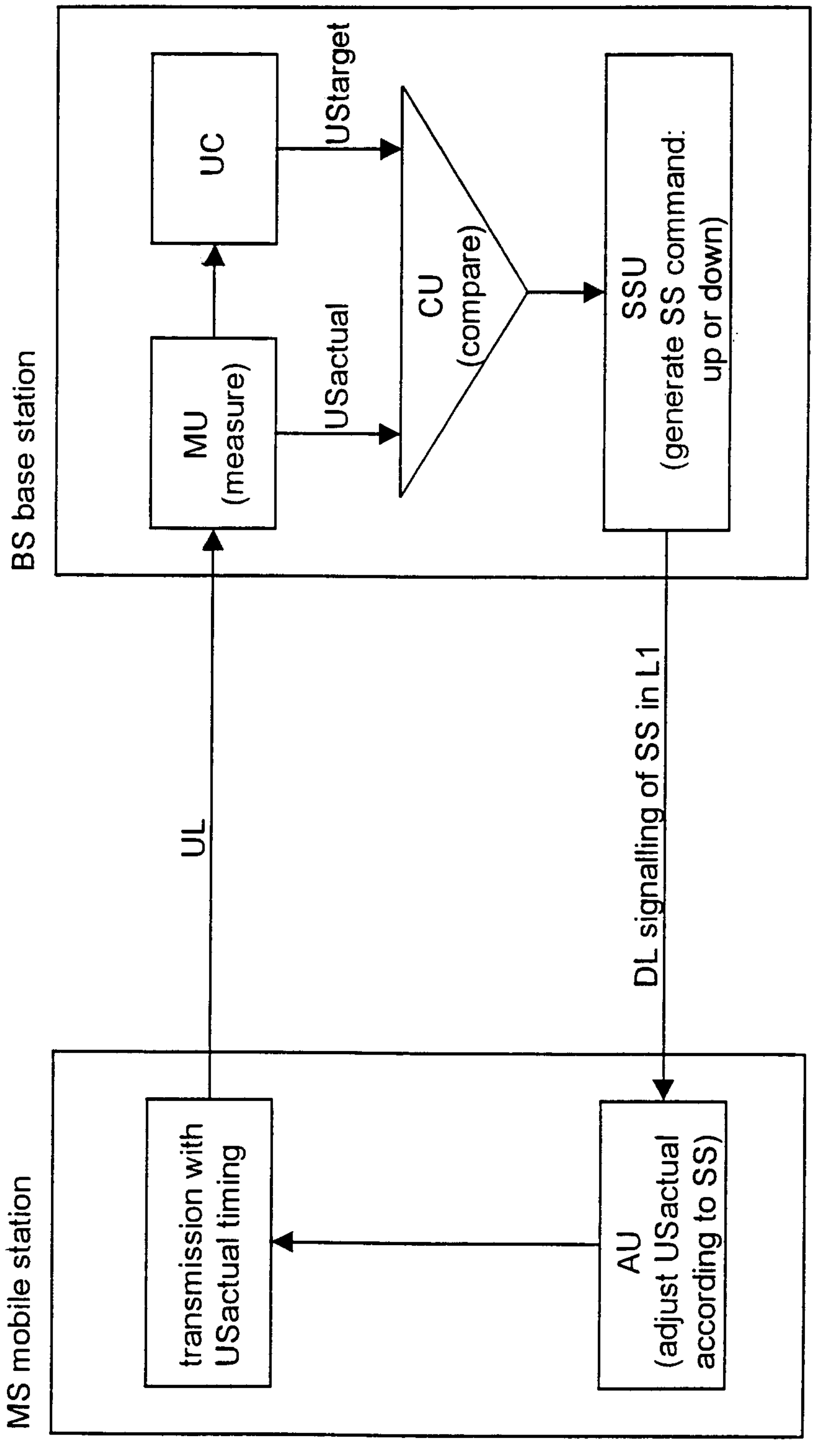

BS base station
MU
(measure)
UC
USactual
UStarget
CU
(compare)
SSU
(generate SS command:
up or down)
UL
DL signalling of SS in L1
MS mobile station
transmission with
USactual timing
AU
(adjust USactual
according to SS)

Fig. 2

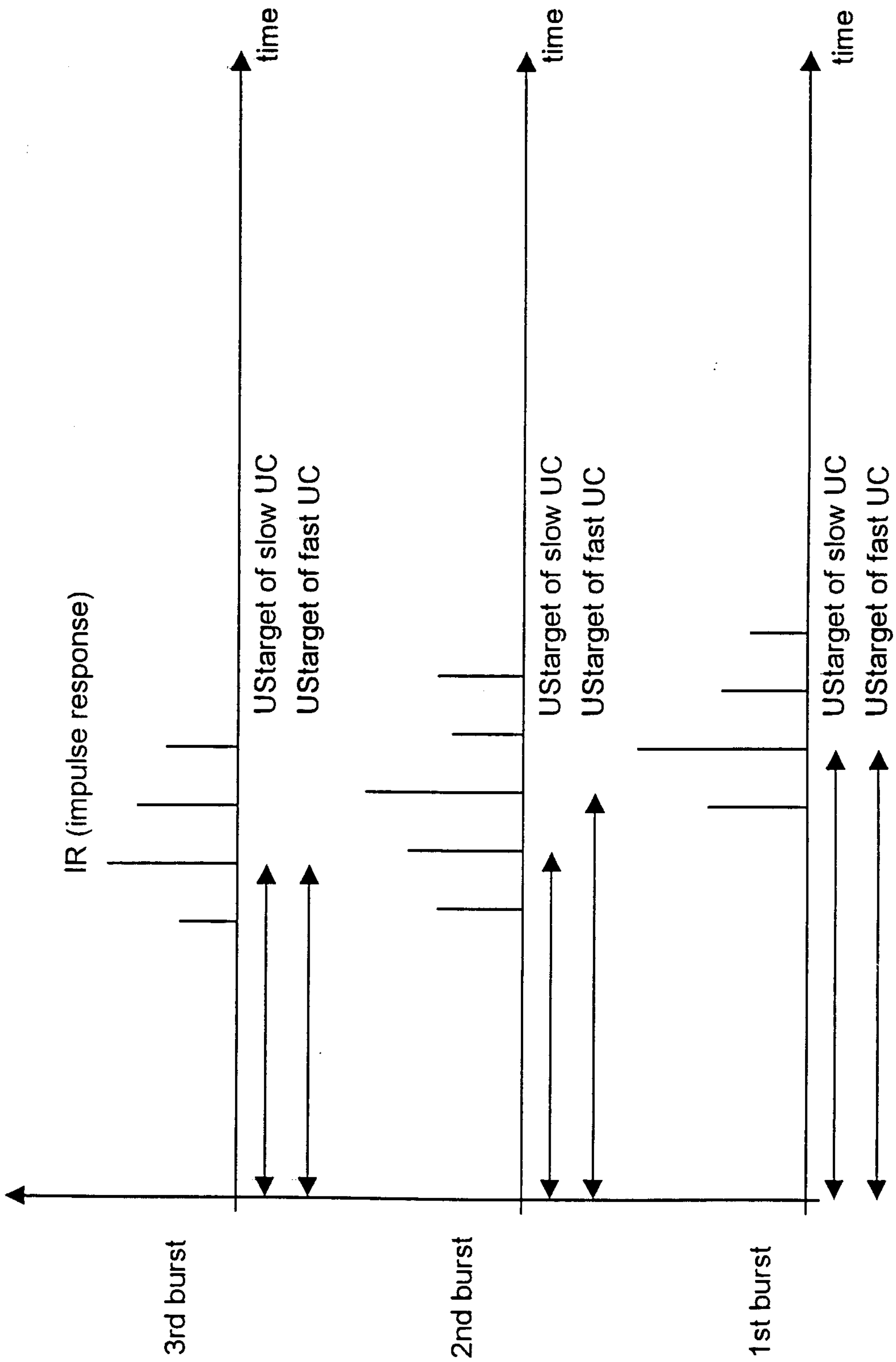

IR (impulse response)
time
UStarget of slow UC
UStarget of fast UC
3rd burst
2nd burst
1st burst

Fig. 3

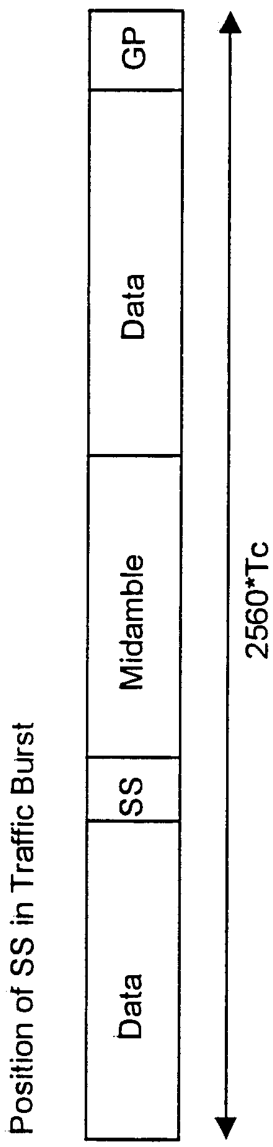

Position of SS in Traffic Burst
Data
SS
Midamble
Data
GP
2560*Tc

Fig. 4

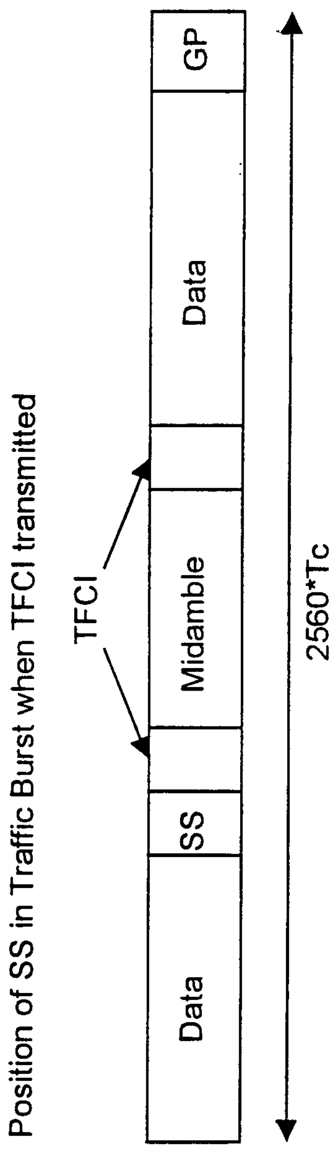

Position of SS in Traffic Burst when TFCI transmitted
TFCI
Data
SS
Midamble
Data
GP
2560*Tc

Fig. 5

INTERNATIONAL SEARCH REPORT

Inte ional Application No
PCT/EP 00/09517

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B H04J

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y		2,8,9, 12,18, 19,22, 28,29
	abstract column 3, line 15 -column 5, line 16 column 7, line 18-30 column 8, line 40-50 column 9, line 11-35 column 9, line 52 -column 11, line 48 figure 3 claims ---	
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
8 March 2001	15/03/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Dejonghe, O

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INTERNATIONAL SEARCH REPORT

Inte..ional Application No
PCT/EP 00/09517

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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			SG	69960	A	25-01-2000
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