

A TELECOMMUNICATIONS SYSTEM SYNCHRONIZATION METHOD

The present invention relates to time-division multiple access (TDMA) telecommunications systems. These systems convey a data signal comprising a synchronization part and a message part in a time window on a radio channel.

In the air interface of the GSM cordless telephone system, it is beneficial to use a mechanism for shifting the time window within the frame on the broadcast control channel to reduce interference with the GSM network and other fixed parts of the GSM cordless telephone system.

The usual shifting rules entail cyclic, random or pseudo-random shifts. However, because the mobile station cannot tell which time slot in the frame was used by the fixed part, cyclic, random or pseudo-random shifts cannot quickly determine the position of the start of the frame of the broadcast control channel without dedicated signaling or without knowing the frame number. In the GSM cordless telephone system, if the shift sequences do not have any particular property the mobile station is unable to find out the frame number quickly by listening only to the broadcast control channel.

A method of determining the start of the frame frequently used in the prior art adds additional signaling to the signal. That solution enables the start of the frame to be found at the cost of overloading the signal, which makes it slower to use or requires a higher bit rate.

The object of the invention is to enable the mobile station to determine the position of the start of the frame of the broadcast control channel as quickly as possible knowing only the fixed part broadcast identifier (FPBI) that is broadcast on the broadcast control channel. The invention also makes it possible to determine the position of the time window within any frame of the broadcast control channel if the frame number and the FPBI are known. In this context, this

minimizes the probability of collusion between the time windows of the broadcast control channel of two fixed parts.

5 The invention provides a method of determining the position of the start of the frame of a fixed part transmitting a time-division multiple access radio signal at a specific frequency in time slots in a local geographical area to communicate with a mobile station in the same geographical area, which method is characterized
10 in that it includes the following steps:

- defining shifting rules;
- defining sequences for shifting the position of the time window in the frame in accordance with the shifting rules, where each sequence defines different
15 shifts from an initial position of the time window and the fixed part transmits the signal in accordance with a specific time window shift sequence;
- memorizing the time slot shifting rules and the time slot shift sequences in the mobile station;
- 20 - searching by the mobile station for a synchronization window transmitted by the fixed part;
- searching by the mobile station for at least one subsequent synchronization window to determine the shifts for each window as a function of the preceding ones in
25 accordance with the shifting rules; and
- determination by the mobile station of the position of the start of the frame of the fixed part from at least one shift determined from a knowledge of the sequences used by the fixed part.

30 The mobile station advantageously identifies the sequence used by the fixed part from signaling transmitted by the fixed part.

The position of the start of the frame can preferably be found from a maximum of two shift
35 measurements. Alternatively, eight fixed parts can transmit in parallel in the same frame without collusion.

In an advantageous embodiment the position of the

time window in the frame can be determined from the frame number.

5 In some embodiments the sequences are divided into sub-sequences and consecutive shift sub-sequences are strung together without repetition of a time slot.

10 The invention also provides a fixed part transmitting a time-division multiple access (TDMA) radio signal at a specific frequency in different time slots in a local geographical area to communicate with a mobile station in the same geographical area using the method according to the invention. It is characterized in that it comprises means for memorizing a time window shift sequence in accordance with the shifting rules, each sequence defines different shifts from an initial position of the time window, and the fixed part transmits the signal in accordance with a specific time window shift sequence.

15 In the same manner, a mobile station receiving time-division multiple access (TDMA) radio signals to communicate with a fixed part in the same geographical area using the same method is characterized in that it comprises means for memorizing shifting rules, means for memorizing a time window shift sequence in accordance with the shifting rules wherein a sequence defines different shifts from an initial position of the time window and the fixed part transmits the signal in accordance with a time window shift sequence previously stored by said mobile station, means for searching for a synchronization window transmitted by the fixed part, means for searching for a subsequent synchronization window to determine shifts for each slot as a function of the preceding ones in accordance with the shifting rules, and means for determining the position of the start of the frame of the fixed part from at least one shift determined in this way.

35 It is possible to identify the position of the start of the frame by looking at the relative position of the

time window of the broadcast control channel in successive frames. Specific sequences are used to obtain optimum performance (fast identification and small observation window). What is more, these shift sequences are constructed from a family of basic sub-sequences in accordance with certain parameters, chosen for each fixed part. The number of parameters for each fixed part is usually limited.

The time window shift sequences are such that it is possible to identify the position of time slot 0 by observing a limited number of successive sequences, for example three successive sequences, without knowing the frame number.

The chaining of the shift sub-sequences is regularly changed in a deterministic way so that it is possible to find the time slot (TN) that will be used within a given frame knowing the fixed part broadcast identifier (FPBI).

A plurality of fixed parts can work in parallel on different time slots without collusion at any time. It is possible to use as many fixed parts as there are time slots in a frame. A frame usually contains eight time slots.

In a preferred embodiment, the system relates to a fixed part (FP) and mobile stations (MS) of a GSM cordless telephone system (CTS). The mobile stations can be in various states: either they are not registered and have no information on the fixed part apart from the fixed part broadcast identifier (FPBI), or they are registered and should know all the parameters of the fixed part, including the current frame number.

Shifting the time window within the frame on the broadcast control channel reduces interference between fixed parts and with the GSM network. It can also be beneficial if the broadcast control channel is not transmitted in a fixed time slot to facilitate its observation by the mobile station.

The shift is defined so that a mobile station that

is not registered can find the position of time slot 0 of the fixed part knowing only the FPBI. A registered mobile station can predict in which time slot the fixed part transmits its broadcast control signal from the frame number and the FPBI.

The shifts advantageously do not exceed four time slots, the risk of collusion between the two fixed parts advantageously has a low probability, and the time slots are advantageously used in an equiprobable manner.

Incorrect determination of the time window is not possible during the change from one shift sub-sequence to another.

Sixteen families of sub-sequences of eight time slot shifts (TSS) are preferably used, each sub-sequence running through the eight possible time slots of a frame. These are used to determine the position of the start of the frame from only three successive observations. The TSS used are also regularly changed in accordance with the frame number and the FPBI.

In an advantageous first embodiment, a zero shift is prohibited in a sub-sequence and on changing from one sub-sequence to another the first time slot of a new sub-sequence is the last time slot of the preceding sub-sequence (it is therefore repeated). This prevents errors in determining the position of the time window, as a zero shift characterizes the sub-sequence change.

If it is not registered, the mobile station searches for a frequency time window transmitted every 52 frames on the broadcast control frequency by the fixed part.

When the time window is found, the synchronization time window is decoded 26 frames later and the FPBI extracted from it. The FPBI is needed to identify the TSS family used. The mobile station then searches for the next frequency time window 52 frames later in a window of nine time slots (from -4 to +4 around the time slot of the frequency time window previously found). The time shift with the time slot of the first frequency time window is

saved (s1). The process is repeated to obtain the second shift value (s2).

Knowing s1, s2 and the TSS family, it is possible to find which time slot is used from the table of sub-sequences. The position of slot 0, and therefore the start of the frame, can then be found. If s1 or s2 is zero, the fixed part was in the process of changing sub-sequence and the procedure must be started over.

If it is registered, a mobile station can seek to predict the broadcast control channel time slot. The family of four sub-sequences used by the fixed part and their order are extracted from the FPBI. The series TSS(0), TSS(1), TSS(2), TSS(3) can be deduced from it. For example, if the choice is made to define 16 families for the CTS, four bits in the FPBI designate which one is used by the fixed part. A series of four sub-sequences is then constructed from this family. The FPBI can indicate, for example: TSS(0) = TSS#1, TSS(1) = TSS#1, TSS(2) = TSS#3, TSS(3) = TSS#1. This requires 4×2 bits in the FPBI to designate the four sub-sequences. The initial time slot (TNI) is also extracted from the FPBI.

Multiframes each comprising 52 frames, subsets, sets and supersets, all of which are defined below, are used to describe the shifts:

- A multiframe contains 52 frames. The broadcast control channel has a multiframe structure. The time slot is the same for the frequency time window and the subsequent synchronization window.

- A subset contains 25 multiframe. The shift is effected in accordance with a particular shift sub-sequence. The last time slot is the same as the first:

$$TN(24) = TN(16) = TN(8) = TN(0).$$

- A set is made up of four subsets and two multiframe. The four subsets, numbered from 0 to 3, use four respective shift sub-sequences TSS(0) to TSS(3) specific to the fixed part. Each set terminates with the two multiframe using the last time slot of subset 3.

For all the subsets of the same set, the first and last time slots are the same. This property is then transmitted to the whole. In a set, the change from one subset to another does not modify the time slot.

- 5 - A superset comprises eight consecutive sets having the following property: the first time slot is shifted in accordance with TSS(0). After the eight sets, the initial configuration returns.

10 The general shift structure has an overall period of one superset, i.e. $16 \times 51 \times 52$ frames.

A second embodiment using the same method but with a different implementation of the sequences and sub-sequences is described below. It has the advantage of not having to repeat a time slot on changing from one sub-sequence to the other. This is made possible by using sub-sequences having additional properties compared to the previous ones. This accelerates the determination of the frame start by a mobile station that is not registered because there is no instance of failure.

20 For a fixed part, an ordered pair of shift sub-sequences is chosen from N predefined pairs. The pair used by the fixed part concerned is indicated in the FPBI (four bits for 16 pairs, for example) and the order within the pair (1st sub-sequence, 2nd sub-sequence) is determined by one bit of the FPBI. The pair is denoted (TSS#1, TSS#2). The N pairs are constructed so that it is possible to determine the start of the frame unequivocally from three successive observations of the broadcast control channel, including a change from one sub-sequence of the pair to the other.

Example of a pair having the required properties:

TSS#1: slot sequence	0 2 1 4 7 6 5 3 0
shift sequence	2 -1 3 3 -1 -1 -2 -3
TSS#2: slot sequence	0 1 5 6 3 7 4 2 0
35 shift sequence	1 4 1 -3 4 -3 -2 -2

A law governing use of the sub-sequences TSS#1 and TSS#2 is then defined so that the time slot to be used

can easily be determined from the frame number. For this purpose, subsets of 17 multiframes are defined, with the following law:

- sub-sequence TSS#1 on x multiframes,
 - 5 - sub-sequence TSS#2 on 8 multiframes,
 - sub-sequence TSS#1 on $9 - x$ multiframes,
- where x is an integer from 1 to 8.

A set is then defined as the string of three subsets, i.e. 51 multiframes. The law governing use of the TSS of a set is:

- sub-sequence TSS#1 on x_1 multiframes,
 - sub-sequence TSS#2 on 8 multiframes,
 - sub-sequence TSS#1 on $(9 - x_1) + x_2$ multiframes,
 - sub-sequence TSS#2 on 8 multiframes,
 - 15 - sub-sequence TSS#1 on $(9 - x_2) + x_3$ multiframes,
 - sub-sequence TSS#2 on 8 multiframes,
 - sub-sequence TSS#1 on $9 - x_3$ multiframes,
- where x_1, x_2, x_3 are integers from 1 to 8.

The numbers x_1, x_2 and x_3 are specific to each fixed part and are determined from the FPBI ($3 \times 3 = 9$ bits in total).

Example for $x_1 = 2, x_2 = 3, x_3 = 5$ and with a first slot equal to 0:

1st subset:

25 TSS used . 1 2 2 2 2 2 2 2 2 1 1 1 1 1 1 1
slot 0 2 0 1 5 6 3 7 4 2 1 4 7 6 5 3 0

2nd subset:

TSS used 1 1 1 2 2 2 2 2 2 2 2 1 1 1 1 1 1
slot 2 1 4 2 0 1 5 6 3 7 4 7 6 5 3 0 2

30 3rd subset:

TSS used 1 1 1 1 1 2 2 2 2 2 2 2 2 1 1 1 1
slot 1 4 7 6 5 6 3 7 4 2 0 1 5 3 0 2 1

In any subset, the sub-sequence TSS#2 is always used for eight successive shifts, and the time slot after the last shift is therefore equal to that before the first shift. The sub-sequence TSS#1 is used for nine shifts in each subset, which creates a shift of 1 in each subset.

For each set, the first time slot is obtained by 3×1 shifts in accordance with the sub-sequence TSS#1 relative to the first time slot of the preceding set.

A superset is defined as a string of eight sets.
 5 8×3 shifts according to the sub-sequence TSS#1 will therefore have been effected, which amounts to a zero shift. The time slot after the last shift of a superset is then identical to the first time slot of the superset. The initial time slot TNI of the supersets is specific to
 10 each fixed part and is identified by three bits of the FPBI.

A pattern is therefore formed with a length of $8 \times 51 \times 52$ frames. The number of different patterns is equal to $(16 \times 2) \times (8 \times 8 \times 8) \times 8 = 2^{17}$, which
 15 corresponds to 17 flagged bits in the FPBI.

In a final embodiment it is also possible to define other laws governing use of sub-sequences TSS#1 and TSS#2 that eliminate the need to define subsets in a set. The resulting embodiment has the advantage of not using the
 20 sub-sequence TSS#2 for only eight successive shifts. The following law can be defined for a set of 51 multiframe, for example:

- sub-sequence TSS#1 on x_5 multiframe,
- sub-sequence TSS#2 on x_4 multiframe,
- 25 - sub-sequence TSS#1 on x_3 multiframe,
- sub-sequence TSS#2 on x_2 multiframe,
- sub-sequence TSS#1 on x_1 multiframe,
- sub-sequence TSS#2 on 8 multiframe,
- sub-sequence TSS#1 on $8 - x_1$ multiframe,
- 30 - sub-sequence TSS#2 on $8 - x_2$ multiframe,
- sub-sequence TSS#1 on $8 - x_3$ multiframe,
- sub-sequence TSS#2 on $8 - x_4$ multiframe,
- sub-sequence TSS#1 on $11 - x_5$ multiframe,

where x_1, x_2, x_3, x_4 are integers from 1 to 7 and x_5 is
 35 an integer from 1 to 10.

The numbers x_1, x_2, x_3, x_4 and x_5 are specific to each fixed part and are determined from the FPBI

$((4 \times 3) + (1 \times 4) = 16 \text{ bits in total}).$

Example for $x_1 = 2$, $x_2 = 3$, $x_3 = 5$, $x_4 = 4$, $x_5 = 7$
and with a first slot (TNI) equal to 0:

5 TSS used . 1 1 1 1 1 1 2 2 2 2 1 1 1 1 1 2 2 2 1 1
slot 0 2 1 4 7 6 5 6 3 7 4 7 6 5 3 0 1 5 6 5 3

TSS used 2 2 2 2 2 2 2 2 1 1 1 1 1 1 2 2 2 2 2 1 1
slot 7 4 2 0 1 5 6 3 0 2 1 4 7 6 3 7 4 2 0 2 1

10

TSS used 1 2 2 2 2 1 1 1 1
slot 4 2 0 1 5 3 0 2 1

15 The property of the set is preserved: for each set,
the first time slot is obtained by three shifts in
accordance with sub-sequence TSS#1 relative to the first
time slot of the preceding set.

20 As in the previous embodiment, the superset is
defined as a string of eight sets. The property that the
time slot after the last shift of a superset is identical
to the first time slot of that superset is therefore
preserved.

25 A pattern is therefore produced with a length of
 $8 \times 51 \times 52$ frames. The number of different patterns is
equal to $(16 \times 2) \times (7 \times 7 \times 7 \times 7 \times 10) \times 8$, which
corresponds to 23 flagged bits in the FPBI.

CLAIMS

1. A method of determining the position of the start of the frame of a fixed part transmitting a time-division multiple access (TDMA) radio signal at a specific frequency in time slots in a local geographical area to communicate with a mobile station in the same geographical area, which method is characterized in that it includes the following steps:
- defining shifting rules;
 - defining sequences for shifting the position of the time window in the frame in accordance with the shifting rules, where each sequence defines different shifts from an initial position of the time window and the fixed part transmits the signal in accordance with a specific time window shift sequence;
 - memorizing the time slot shifting rules and the time slot shift sequences in the mobile station;
 - searching by the mobile station for a synchronization window transmitted by the fixed part;
 - searching by the mobile station for at least one subsequent synchronization window to determine the shifts for each window as a function of the preceding ones in accordance with the shifting rules; and
 - determination by the mobile station of the position of the start of the frame of the fixed part from at least one shift determined from a knowledge of the sequences used by the fixed part.
2. A fixed part frame start position determination method according to claim 1, characterized in that the sequence used by the fixed part is identified by the mobile station from signaling transmitted by the fixed part.
3. A fixed part frame start position determination method according to either preceding claim, characterized in that the start of the frame can be found from a



maximum of two shift measurements.

4. A fixed part frame start position determination method according to any preceding claim, characterized in that eight fixed parts can transmit in parallel in the same frame without collusion.

5. A fixed part frame start position determination method according to any preceding claim, characterized in that the position of the time window in the frame can be determined from the frame number.

6. A fixed part frame start position determination method according to any preceding claim, characterized in that the sequences are divided into sub-sequences.

7. A fixed part frame start position determination method according to any preceding claim, characterized in that consecutive shift sub-sequences are strung together without repeating a time slot.

8. A fixed part transmitting a time-division multiple access (TDMA) radio signal at a specific frequency in different time slots in a local geographical area to communicate with a mobile station in the same geographical area using the method according to claim 1, characterized in that it comprises means for memorizing a time window shift sequence in accordance with the shifting rules, each sequence defines different shifts from an initial position of the time window, and the fixed part transmits the signal in accordance with a specific time window shift sequence.

9. A mobile station receiving time-division multiple access (TDMA) radio signals to communicate with a fixed part in the same geographical area using the method according to claim 1, characterized in that it comprises



means for memorizing shifting rules, means for memorizing a time window shift sequence in accordance with the shifting rules where a sequence defines different shifts from an initial position of the time window and the fixed part transmits the signal in accordance with a time window shift sequence previously stored by said mobile station, means for searching for a synchronization window transmitted by the fixed part, means for searching for a subsequent synchronization window to determine shifts for each slot as a function of the preceding ones in accordance with the shifting rules, and means for determining the position of the start of the frame of the fixed part from at least one shift determined in this way.

