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(54) **METHOD FOR SYNCHRONIZATION OF TRANSMITTER AND RECEIVER IN MOBILE RADIO SYSTEMS**

VERFAHREN ZUR SYNCHRONISIERUNG VON SENDER UND EMPFÄNGER IN MOBILEN FUNKSYSTEMEN

PROCEDE DE SYNCHRONISATION D'UN EMETTEUR ET D'UN RECEPTEUR DANS DES SYSTEMES RADIOTELEPHONIQUES MOBILES

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EP-A- 218 966 **EP-A- 0 218 966**
DE-C- 3 401 727 **SE-C- 500 986**
US-A- 5 208 812

Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to synchronization of MC/DS-CDMA-systems. The invention accordingly relates to mobile radio systems for multicarrier/direct sequence code divided multiple access, MC/DS-CDMA. The technology is a combination of OFDM, orthogonal frequency division multiplexing, and traditional DS-CDMA, direct sequence CDMA.

10 PRIOR ART

[0002] It is previously known to transmit information in a data channel where the digital information is divided into a number of different blocks. The blocks are separated by guard spaces. The task of the guard spaces is to deal with the time dispersion on the channel. Further, it is known to arrange a pilot channel with the same block division and guard spaces as the data channel. Transmission units transmits a cyclic pilot sequence which is unique within the range possible to listen in to.

15 **[0003]** A base station always transmits a unique pilot sequence. This causes that a recently turned on mobile station identifies the base station/stations which are located within the range possible to listen in to. A mobile station transmits one of two different types of pilot sequences. A so called random access sequence is transmitted when a mobile station wants to make a connection to a base station. By the random access sequence being used only for this purpose, and being unique for each mobile station, the base station knows that a mobile station wants to establish a connection to it. The other type of pilot sequence the mobile station transmits during an established connection. The mobile station has been given both uplink sequences from the base station.

20 **[0004]** In the German patent document DE 3401727 is described a TDM-system for transmission of digital information which uses a synchronization channel. The synchronization channel also can contain other information, as for instance information about other performing channels.

25 **[0005]** In the European patent document EP 606941 is described a device for synchronization of a local oscillator in a OFDM-system.

30 **[0006]** The document WO 92-5646 describes reception of OFDM-signals. To achieve synchronization, a multiplication with the complex conjugate of a known reference is performed.

[0007] In the document WO 92-16063 is described reception and synchronization in an OFDM-system. According to the document, reference symbols are placed at least one carrier from the edge of the frequency raster, and at least two carriers from other reference symbols.

35 **[0008]** The European document EP 218966 describes a TDMA-system intended for radio transmission. To achieve a synchronization as good as possible, a special signal is introduced into each free time slot.

DESCRIPTION OF THE INVENTION

TECHNICAL PROBLEM

40 **[0009]** At transmission of packet switched digital signals between a transmitting and a receiving equipment in a communications system it is necessary to have the possibility to synchronize the signal transmission to obtain usable information in the receiving equipment. For the message transport between the transmitter and the receiver a number of access methods have been developed, of which MC/DS-CDMA is one. The method is a combination of OFDM and traditional DS-CDMA.

45 **[0010]** In an OFDM-system the pilot frequencies often become long, for instance $N=512$ och 1024 . Such long correlations are possible but very voluminous to implement by means of digital hardware for convolution. Since one in an OFDM-system always has the signals available both in the time and frequency plane, it is attractive to implement the correlation by means of multiplication in the frequency plane. A process which demands $N*N$ complex multiplications per frame is then exchanged for another which demands N complex multiplications per frame. This is, however, not easy to perform since the OFDM-system operates with guard spaces (Δ). The Fouriertransform of the data channel is performed with the block length N . If the pilot channel is synchronous with the data channel, the pilot channel is cyclic with the repeating distance $N+\Delta$. In order to perform the correlation in the frequency plane, one has to use a block length which is equal to the repeating distance. With this arrangement one cannot, accordingly, use the same block of data for the Fouriertransforms, and the method is consequently not usable.

55 **[0011]** It is, accordingly, desirable to find methods where the same block length can be used both in the data channel and in the pilot channel. The present invention is intended to solve the above indicated problem.

THE SOLUTION

5 **[0012]** The present invention relates to a method for synchronization of MC/DS-CDMA-systems. The information is transmitted in a data channel in blocks which are separated by guard spaces. In a further channel are arranged blocks which follow each other successively without guard spaces between the blocks. The blocks in the further channel are placed in relation to the blocks in the data channel, at which the relation between the blocks appoints the position of the data channel, and synchronization of the receiver and the transmitter is achieved.

10 **[0013]** The invention accordingly relates to a system where transmitter and receiver at mobile radio system transmits information digitally in frames. A number of frames form a block, and different blocks in the data channel are separated by guard spaces. A synchronization and a pilot channel are created. The information in these channels are divided into blocks, and the blocks are arranged in direct sequence after each other without guard spaces between the blocks. The blocks in the pilot channel are displaced in relation to the blocks in the data channel. The information in the blocks in the synchronization channel indicates the relation of the blocks to the data channel, and the blocks of the pilot channel are synchronized with the blocks in the synchronization channel, thus the relation of the blocks to each other identifies the position of the data channel, and synchronization of the receiver and the transmitter is achieved.

15 **[0014]** The information in the synchronization and pilot channels is cyclic. The blocks in the data channel and in the pilot channel have the same length. The cycle in the synchronization channel corresponds to a certain number of blocks in the data channel.

20 **[0015]** Information in the blocks in the synchronization channel indicates the relation of the block to the data channel. Decoding of the information in the synchronization channel indicates the position of the data channel. The blocks of the pilot channel are arranged after each other without guard spaces between the blocks. The blocks of the pilot channel are synchronized with the blocks in the synchronization channel, as mentioned above.

25 **[0016]** The blocks of the pilot channel are cyclically repeated with a period corresponding to the length of a block in the data channel. The position of the pilot channel indicates the position of the synchronization channel. The same blocks and data are used for decoding of information and synchronization, which is made possible by the length of the blocks in the data channel and the pilot channel being given the same length. The system is an MC/DS-CDMA-system.

[0017] The invention consequently relates to a method in mobile radio systems for synchronization of transmitter and receiver. The system relates to an MC/DS-CDMA-system.

30 In the system, information is transmitted digitally in frames, and a data channel, a pilot channel and a synchronization channel are created. In the data channel the data blocks D0, D1, D2 etc, are separated by guard spaces Δ . In the pilot-respective synchronization channel the information is arranged in synchronous blocks. The repeating distance of the pilot channel, A, corresponds to the length of one of the data blocks D0, D1, D2 etc. The repeating distance of the synchronization channel, S, corresponds to a number of blocks in the data channel. In the synchronization channel, information is introduced into the blocks and indicates their relation to the data channel.

35 Identification of the position of the pilot channel indicates the position of the data channel, and the information in the synchronization channel indicates the position of the data channel.

ADVANTAGES

40 **[0018]** The present invention allows that correlation by means of multiplication in the frequency plane can be performed with N complex multiplications per frame. This should be compared with N*N complex multiplications which in other cases would be required.

45 **[0019]** The Fouriertransform is performed on data channel and pilot channel on blocks of the same length. In the normal case the Fouriertransform had to be performed on different lengths of blocks in the data channel respective for the pilot channel.

[0020] Further one utilizes the same blocks of data for Fouriertransform on the channels.

[0021] The synchronization channel indicates a relative relationship to the frames in the data channel. This is utilized for appointing where in the data channel one is at present.

50 **[0022]** The pilot channel indicates the position of the synchronization channel. Furthermore the same data are used for information decoding and synchronization.

DESCRIPTION OF FIGURES

55 **[0023]**

Figure 1 shows block division for a data channel with the blocks D1, D2, D3 etc, separated by a guard space Δ .

Figure 2 shows a data channel with the blocks D0, D1, D2 etc, separated by guard space Δ . Further is shown a

pilot channel, with the blocks P0, which are directly following each other. In addition there is in the figure shown a synchronization channel with the blocks S0, S1, S2 etc.

Figure 3 shows in principle a base station, BS, and a mobile station, MS.

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PREFERRED EMBODIMENT

[0024] In the following the invention is described with reference to the figures and the designations therein.

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[0025] In a mobile radio system according to Figure 3 base stations, BS, are arranged. The mentioned base stations communicate with mobile stations, MS. The information is digitally transmitted in frames.

MC/DS-CDMA means Multi Carrier / Direct Sequence Code Divided Multiple Access. The technology is a combination of OFDM, Orthogonal Frequency Division Multiplexing, and traditional DS-CDMA (Direct Sequence CDMA). The principle for MC/DS-CDMA is based on the information being divided into frames. The transmitted time discrete signal $s_k(i)$ for the frame k with the length T , and with N sample, can be described as:

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$$s_k(i) = a_0 \sum_{n=0}^{\frac{N-l}{M}-1} c_n e^{-j2\pi\xi_k(f_n)t_i} + \dots + a_{M-1} \sum_{n=\frac{N-l}{M}(M-1)}^{\frac{N-l}{M}M-1} c_n e^{-j2\pi\xi_k(f_n)t_i} + \dots + \sum_{n=N-l}^{N-1} e^{-j2\pi\xi_k(f_n)t_i}$$

20

Where $i = (N-\Delta), \dots, (N-1), 0, \dots, (N-1)$

25

A frame F_k is then represented by:

$$F_k = [s_k(N-\Delta), \dots, s_k(N-1), s_k(0), \dots, s_k(N-1)]$$

30

Δ constitutes the so called guard space which aims at managing the time dispersion on the channel. For making it possible to perform an FFT, then $N=2^p$, where l is an integer. The number of symbols which are transmitted per frame is indicated by M . The relation between the total number of subcarriers N and the number of subcarriers which each symbol is spread out over (the distribution factor) R , is then indicated by:

35

$$MR = N-l$$

$N-l$ is the number of subcarriers which in a frame are active, i.e. carriers of information. Consequently then the number of inactive subcarriers is l (lower-case letter l). c_n is the distribution sequence by which every symbol is distributed. This can be repetitive over each symbol or have the same length as the frame. The function $\xi_k(f_n)$ performs the interleaving in the frequency plane according to suitably chosen algorithm. The combination between the last sum in the formula and $\xi_k(f_n)$ accounts for the shaping of the spectra with a necessary pass band beside the active subcarriers in order to, after that, to be able to filter away Nyquist-copies.

40

[0026] The technology is intended to be used in a cellular system for mobile radio communication with full duplex, where the connection from the stationary unit (the Base station, BS) to the mobile unit (the mobile station, MS) is denominated as the downlink. The reverse direction is called the uplink.

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[0027] The synchronization method is based upon that each uplink or downlink consists of at least two coded, physical channels. These are called data channel and pilot channel according to Figure 1. Each transmitting unit, base station or mobile station, transmits a cyclic pilot sequence which is unique within the area which is possible to listen in to.

50

[0028] In the data channel blocks are called D0, D1, D2 etc, separated by guard spaces Δ . Further a pilot channel is arranged with the blocks P0 where guard space Δ between the blocks is lacking.

55

[0029] A base station always transmits a unique pilot sequence. This makes that a recently turned on mobile station identifies the base station/stations which are within the covered range. A mobile station transmits one of two different types of pilot sequences. A so called random access sequence is transmitted from a mobile station which wants to make a connection to a base station. By the random access sequence being used for only this purpose, and being unique for each base station, the base station knows that a mobile station wants to get into contact with it. The other type of pilot sequence is transmitted from the mobile station during an established connection. The sequence is unique for each transmitting mobile station. Both uplink sequences have the mobile station been given by the base station.

Allocation of the uplink sequence is performed according to methods which are well known for persons with expert knowledge in the field.

[0030] To be able to find a pilot sequence, and also after that to be able to use the sequence for synchronization in time and frequency and for channel estimation as well, one has to perform correlations in the receiver. In an OFDM-system the pilot sequences become long, for instance 512 or 1024. Such long correlations are possible but voluminous to implement by means of digital hardware for convolution. Since the signals in an OFDM-system always are available both in the time and frequency plane, it is desirable to implement the correlation by means of multiplication in the frequency plane. In this case one exchanges a process which requires N^2 complex multiplications per frame for another process with N complex multiplications per frame. To perform this in an OFDM-system is, however, not simple with guard spaces being used. The Fouriertransform of the data channel is performed with a block length N . If the pilot channel is synchronous with the data channel, the pilot channel is cyclic and the repeating distance is $N + \Delta$. In order to perform correlations in the frequency plane one has to use a block length which is equal to the repeating distance. The arrangement consequently does not allow use of the same block of data for the Fouriertransforms and the method is therefore not practically usable.

[0031] The fundamental idea of the invention is shown in Figure 2. In this case the pilot channel is repeated with repeating distance N without any guard space A being added. The position of the pilot channel in relation to the data channel is then changed from frame to frame. In the figure this is evident from the fact that the pilot channels P_0 get different positions in relation to the data channel D_0, D_1, D_2 etc. Further is introduced a synchronization channel where the frames are modulated and among other things marked with the relative position of the frame in relation to the frames in the data channel. In the figure the synchronization frames are designated S_0, S_1, S_2 etc. The synchronization channel is synchronous with the pilot channel. By identifying the position of the pilot channel the position of the synchronization channel is also identifiable. The information of the synchronization channel is decoded, at which the position of the data channel is identifiable. By the repeating distance of the pilot channel being equal to the block length of the data channel, the same block of data is usable for information decoding and synchronization.

Claims

1. Method for synchronization of transmitter and receiver in mobile radio systems, wherein information transmission is performed digitally in frames and a number of frames creates a block, blocks (D_0, D_1, D_2, \dots) in a data channel being separated by guard spaces (Δ), and wherein further channels are provided, **characterized in that** said further channels comprise a synchronization channel and a pilot channel, **in that** the information in said synchronization and pilot channels are divided into blocks (S_0, S_1, S_2, \dots ; P_0, P_1, P_2, \dots) which are arranged in direct sequence after each other without guard spaces between the blocks, **in that** the blocks in the data channel and in said pilot channel have the same length, **in that** the blocks (P_0, P_1, P_2, \dots) in said pilot channel are displaced in relation to the blocks (D_0, D_1, D_2, \dots) in the data channel, **in that** the information in the blocks (S_0, S_1, S_2, \dots) of the synchronization channel indicates the relation of the blocks to the data channel, and **in that** the blocks (P_0, P_1, P_2, \dots) of the pilot channel are synchronized with the blocks (S_0, S_1, S_2, \dots) in the synchronization channel, wherein the pilot and synchronization channels are decoded, thus identifying the position of the data channel, and synchronization of receiver and transmitter is achieved.
2. Method according to claim 1, **characterized in that** blocks (S_0, S_1, S_2, \dots) in the synchronization channel are arranged in a cyclic sequence.
3. Method according to claims 1 or 2, **characterized in that** the cycle of blocks (S_0, S_1, S_2, \dots) in the synchronization channel is given the same length as a certain number of blocks (D_0, D_1, D_2, \dots) in the data channel.
4. Method according to any of the previous claims, **characterized in that** decoding of the information in the synchronization channel indicates the position of the data channel.
5. Method according to any of the previous claims, **characterized in that** the blocks (P_0, P_1, P_2, \dots) of the pilot channel are repeated cyclically with a period (A) corresponding to the length of a block (D_0, D_1, D_2, \dots) in the data channel.
6. Method according to any of the previous claims, **characterized in that** the position of the pilot channel indicates the position of the synchronization channel.
7. Method according to any of the previous claims, **characterized in that** the same block of data is utilized for infor-

mation decoding and synchronization, which is made possible by the block length in the data channel and the pilot channel being given the same length.

8. Method according to any of the previous claims, **characterized in that** the system is an MC/DS-CDMA-system.

9. Method according to any of the previous claims, **characterized in that** correlation of data and pilot channels is implemented by means of multiplication in the frequency plane.

Patentansprüche

1. Verfahren zur Synchronisierung von Sender und Empfänger in Mobilfunksystemen, wobei Informationsübertragung digital in Rahmen durchgeführt wird und eine Anzahl von Rahmen einen Block erzeugt, wobei Blöcke (D0, D1, D2, ...) in einem Datenkanal durch Sicherheitsabstände (Δ) getrennt werden und wobei weitere Kanäle bereitgestellt werden, **dadurch gekennzeichnet, daß** die weiteren Kanäle einen Synchronisierungskanal und einen Pilotkanal umfassen, daß die Informationen in den Synchronisierungs- und Pilotkanälen in Blöcke (S0, S1, S2, ...; P0, P1, P2, ...) aufgeteilt werden, die in direkter Reihenfolge nacheinander ohne Sicherheitsabstände zwischen den Blöcken angeordnet sind, daß die Blöcke im Datenkanal und im Pilotkanal dieselbe Länge aufweisen, daß die Blöcke (P0, P1, P2, ...) im Pilotkanal in bezug auf die Blöcke (D0, D1, D2, ...) im Datenkanal versetzt sind, daß die Information in den Blöcken (S0, S1, S2, ...) des Synchronisierungskanals die Beziehung der Blöcke zum Datenkanal anzeigen, und daß die Blöcke (P0, P1, P2, ...) des Pilotkanals mit den Blöcken (S0, S1, S2, ...) im Synchronisierungskanal synchronisiert sind, wobei die Pilot- und Synchronisierungskanäle decodiert werden, wodurch die Lage des Datenkanals identifiziert wird und Synchronisation von Empfänger und Sender erreicht wird.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** Blöcke (S0, S1, S2, ...) im Synchronisierungskanal in zyklischer Reihenfolge angeordnet sind.

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** dem Zyklus von Blöcken (S0, S1, S2, ...) im Synchronisierungskanal dieselbe Länge wie einer gewissen Anzahl von Blöcken (D0, D1, D2, ...) im Datenkanal gegeben wird.

4. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** die Decodierung der Information im Synchronisierungskanal die Lage des Datenkanals anzeigt.

5. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** die Blöcke (P0, P1, P2, ...) des Pilotkanals zyklisch mit einer der Länge eines Blocks (D0, D1, D2, ...) im Datenkanal entsprechenden Periode (A) wiederholt werden.

6. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** die Lage des Pilotkanals die Lage des Synchronisierungskanals anzeigt.

7. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** derselbe Datenblock für die Informationsdecodierung und die Synchronisierung benutzt wird, was dadurch ermöglicht wird, daß der Blocklänge im Datenkanal und dem Pilotkanal dieselbe Länge erteilt wird.

8. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** das System ein MC/DS-CDMA-System ist.

9. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, daß** die Korrelation von Daten- und Pilotkanälen mittels einer Multiplikation in der Frequenzebene realisiert wird.

Revendications

1. Procédé de synchronisation d'un émetteur et d'un récepteur dans des systèmes de radiotéléphonie mobile, dans lequel la transmission des informations est effectuée numériquement en trames et un certain nombre de trames crée un bloc, les blocs (D0, D1, D2, ...) dans un canal de données étant séparés par des espaces de protection (Δ), et dans lequel d'autres canaux sont prévus, **caractérisé en ce que** les dits autres canaux comprennent un

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canal de synchronisation et un canal pilote, **en ce que** les informations dans le dit canal de synchronisation et le dit canal pilote sont divisées en blocs (S0, S1, S2, ...; P0, P1, P2, ...) qui sont agencés en une séquence directe les uns après les autres sans espaces de protection entre les blocs, **en ce que** les blocs dans le canal de données et dans le dit canal pilote ont la même longueur, **en ce que** les blocs (P0, P1, P2, ...) dans le dit canal pilote sont déplacés par rapport aux blocs (D0, D1, D2, ...) dans le canal de données, **en ce que** les informations dans les blocs (S0, S1, S2, ...) du canal de synchronisation indiquent la relation des blocs au canal de données, et **en ce que** les blocs (P0, P1, P2, ...) du canal pilote sont synchronisés avec les blocs (S0, S1, S2, ...) dans le canal de synchronisation, dans lequel le canal pilote et le canal de synchronisation sont décodés, afin d'identifier la position du canal de données, et la synchronisation du récepteur et de l'émetteur est réalisée.

2. Procédé selon la revendication 1, **caractérisé en ce que** les blocs (S0, S1, S2, ...) dans le canal de synchronisation sont agencés en une séquence cyclique.
3. Procédé selon la revendication 1 ou 2, **caractérisé en ce qu'on** donne au cycle de blocs (S0, S1, S2, ...) dans le canal de synchronisation la même longueur qu'un certain nombre de blocs (D0, D1, D2, ...) dans le canal de données.
4. Procédé selon une quelconque des revendications précédentes, **caractérisé en ce que** le décodage des informations dans le canal de synchronisation indique la position du canal de données.
5. Procédé selon une quelconque des revendications précédentes, **caractérisé en ce que** les blocs (P0, P1, P2, ...) du canal pilote sont répétés cycliquement avec une période (A) correspondant à la longueur d'un bloc (D0, D1, D2, ...) dans le canal de données.
6. Procédé selon une quelconque des revendications précédentes, **caractérisé en ce que** la position du canal pilote indique la position du canal de synchronisation.
7. Procédé selon une quelconque des revendications précédentes, **caractérisé en ce que** le même bloc de données est utilisé pour le décodage et la synchronisation des informations, ce qui est rendu possible **en ce qu'on** donne la même valeur à la longueur de bloc dans le canal de données et le canal pilote.
8. Procédé selon une quelconque des revendications précédentes, **caractérisé en ce que** le système est un système à porteuses multiples / accès multiple par répartition en code-à séquence directe MC/DS-CDMA.
9. Procédé selon une quelconque des revendications précédentes, **caractérisé en ce qu'une** corrélation du canal de données et du canal pilote est réalisée au moyen d'une multiplication dans le plan des fréquences.

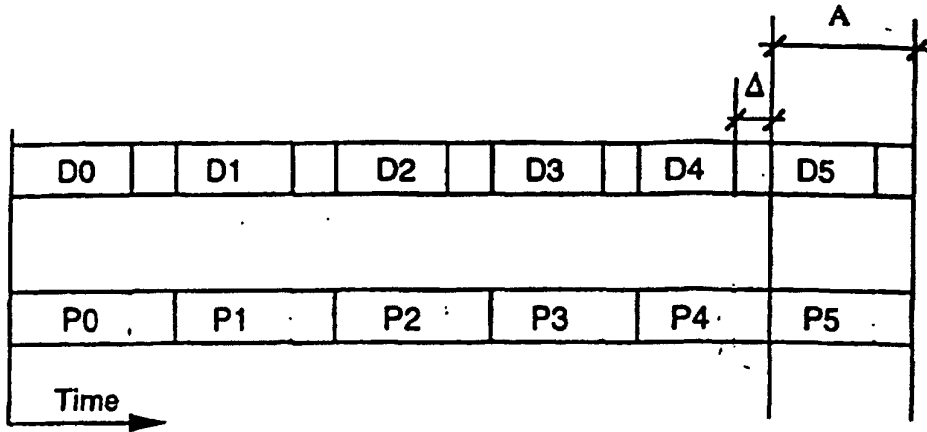


Fig 1

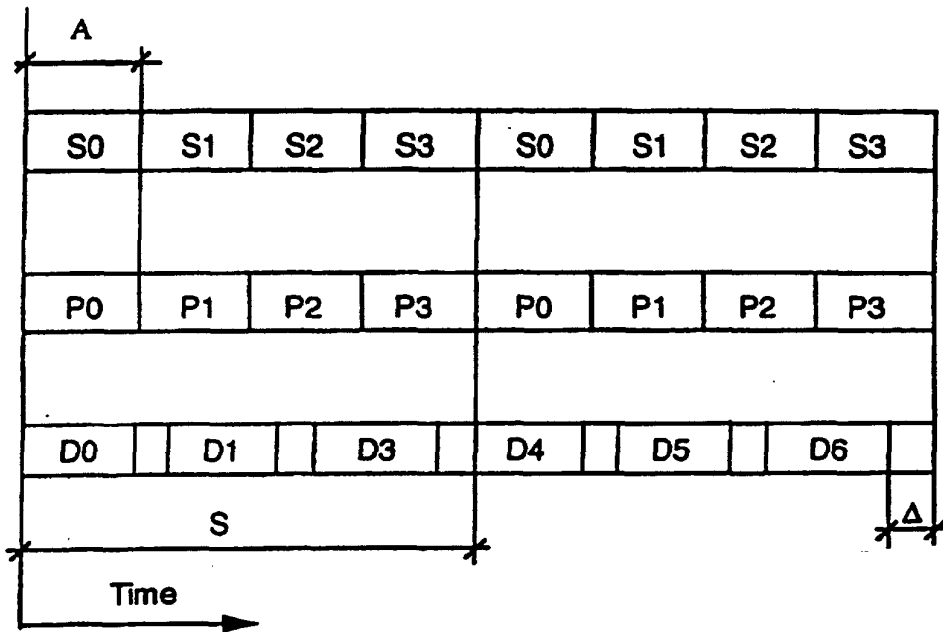


Fig 2



Fig 3