



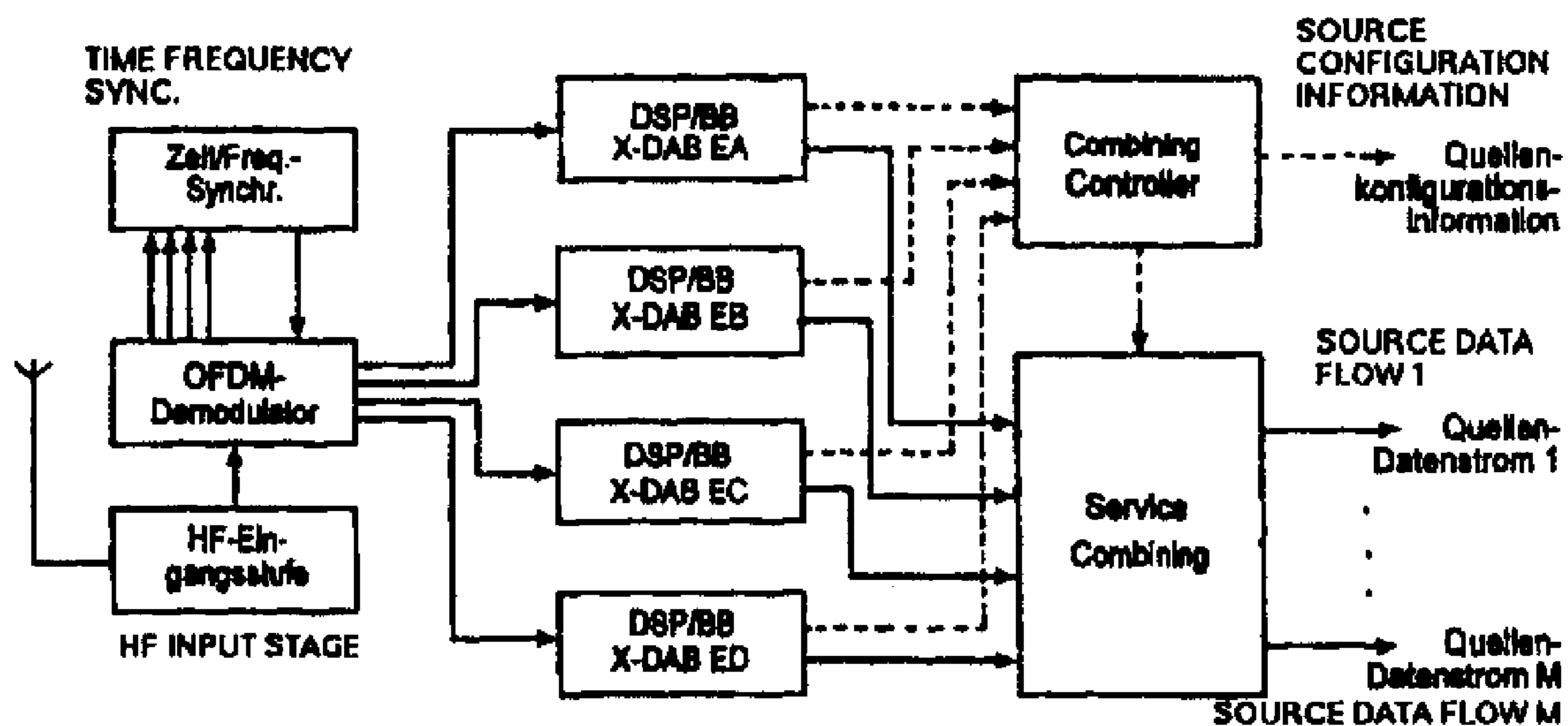
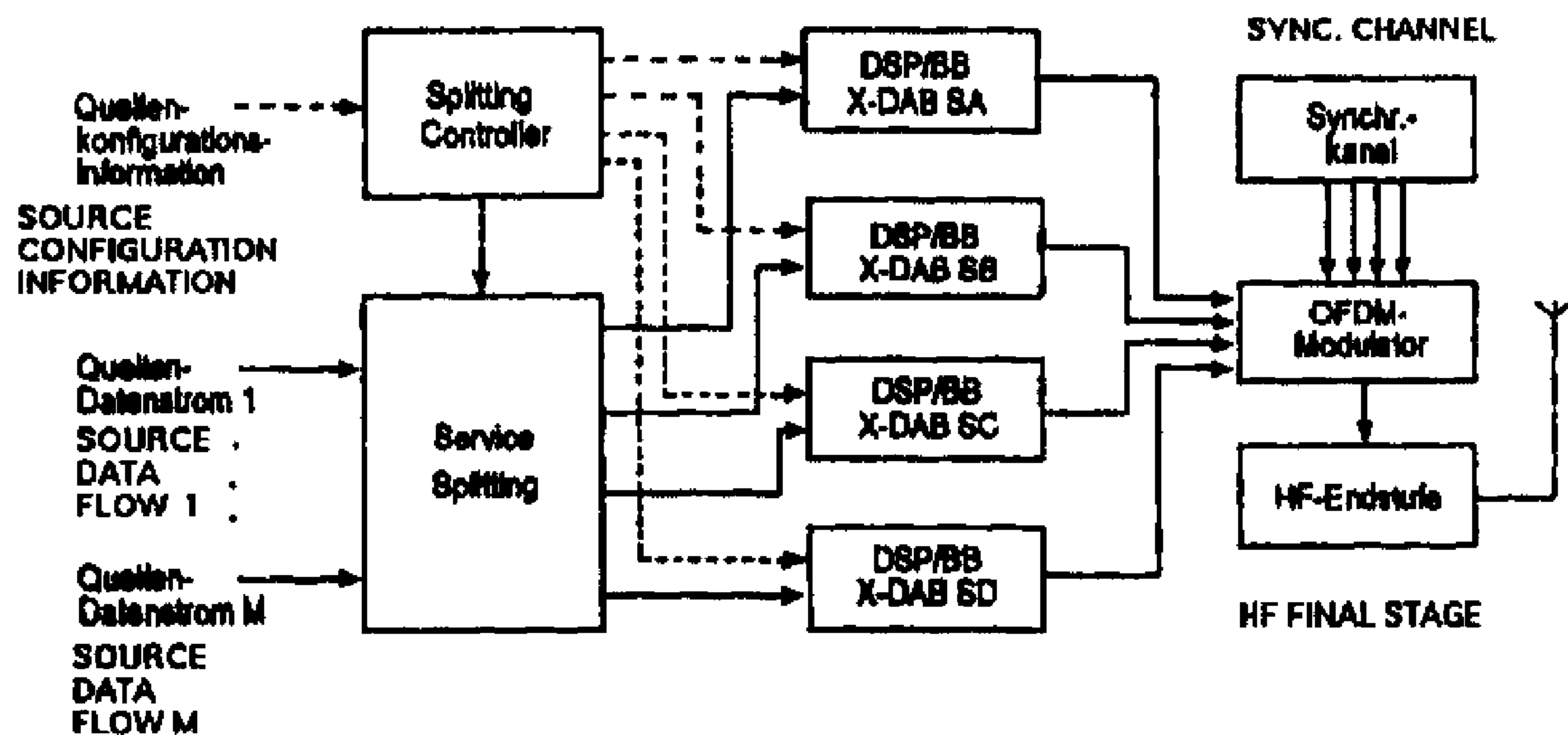
(72) ZIMMERMANN, GERD, DE
(72) SCHULZE, HENRIK, DE
(71) DEUTSCHE TELEKOM AG, DE

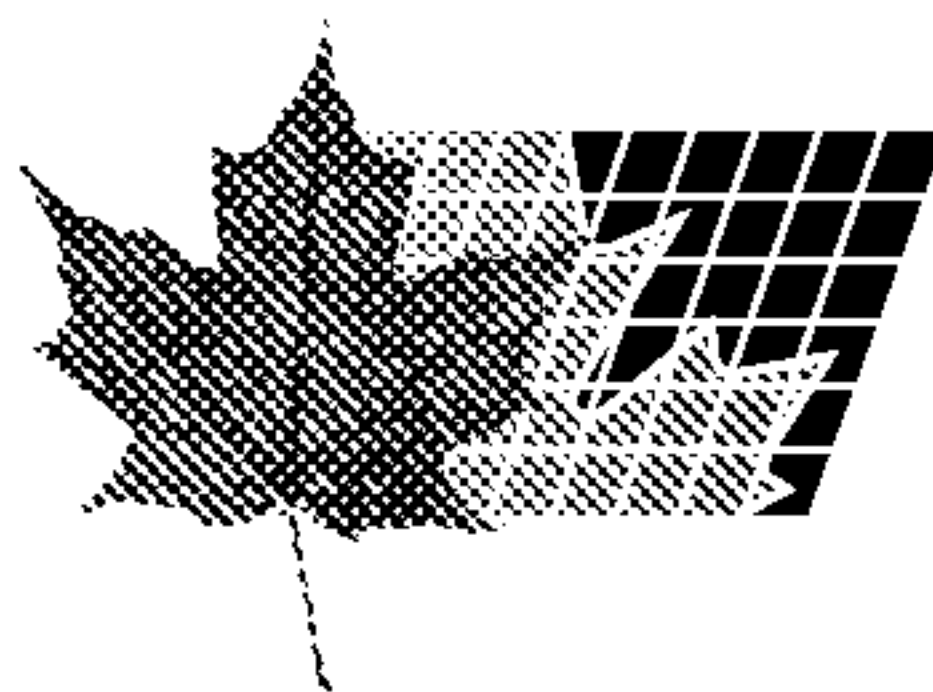
(51) Int.Cl.⁷ H04H 1/00

(30) 1997/04/11 (197 15 022.5) DE

(54) **SYSTEME POUR LA TRANSMISSION D'UTILITAIRES
MULTIFORMES A CADENCE RAPIDE DANS LA
RADIOCOMMUNICATION NUMERIQUE TERRESTRE**

(54) **SYSTEM FOR TRANSMITTING HIGH-SPEED ADDED-VALUE
SERVICES IN TERRESTRIAL DIGITAL BROADCASTING**





(21) (A1) **2,290,596**
(86) 1998/03/21
(87) 1998/10/22

(57) L'invention concerne un système d'émission/réception de radiodiffusion audionumérique élargie à blocs multifréquentiels à large bande pour la transmission sans interférences d'utilitaires multiformes, à débit élevé, à des récepteurs mobiles à l'intérieur d'un canal de télévision analogique. Le concept de ce système offre une grande souplesse au niveau des profils de contrôle d'erreurs et également des débits binaires et permet la réalisation de profils de contrôle d'erreurs non pondérés de même qu'une transmission hiérarchisée. L'invention concerne également un procédé pour envoyer des utilitaires multiformes à cadence rapide à des abonnés mobiles, selon le système de radiodiffusion audionumérique élargie, sur la base de plusieurs, notamment quatre blocs fréquentiels de radiodiffusion audionumérique élargie juxtaposés émettant simultanément dans un réseau sur fréquence commune, blocs sur lesquels est multiplexé un train de données d'entrée numériques codées à la source en fonction du contenu de l'utilitaire respectif.

(57) The invention relates to a broad-band multi-frequency block X-DAB transceiver system for interference-free transmission of high data speed value-added services to mobile receivers in an analog TV channel. The system provides considerable flexibility with regard to error control profiles and therefore data rates, and enables unbalanced error control profiles and hierarchic transmission to be carried out. The invention discloses a method for transmitting high-speed added-value services to mobile subscribers according to the X-DAB system (Extended Digital Broadcasting System) based on several, mainly four, simultaneously broadcast adjacent X-DAB frequency blocks in a common wave network in which relevant service content corresponding to source coded digital input data flow is multiplexed.





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(54) Title: SYSTEM FOR TRANSMITTING HIGH-SPEED ADDED-VALUE SERVICES IN TERRESTRIAL DIGITAL BROADCASTING

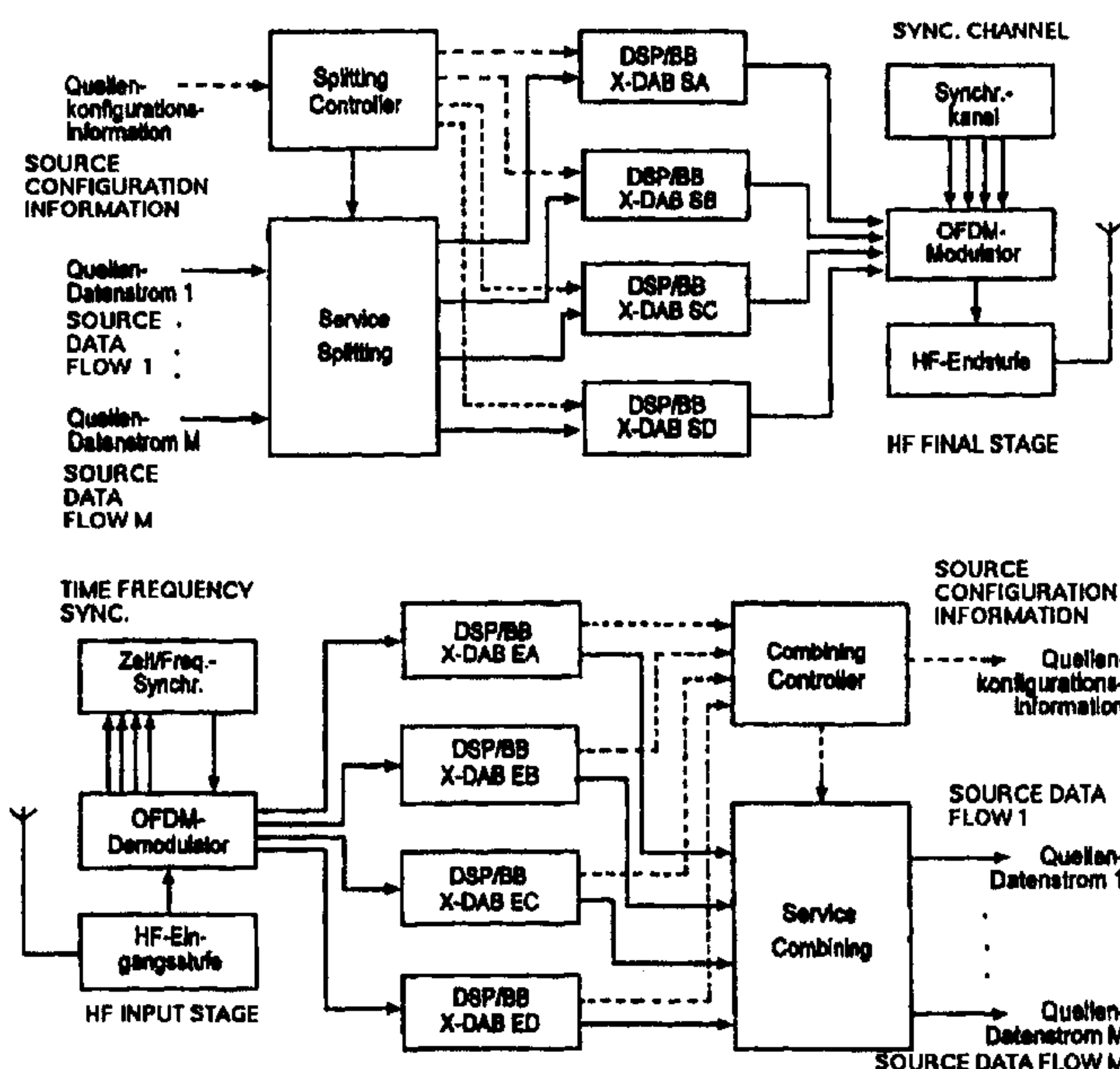
(54) Bezeichnung: SYSTEM ZUR ÜBERTRAGUNG HOCHRATIGER MEHRWERTDIENSTE IM TERRESTRISCHEN DIGITALEN RUNDfunk

(57) Abstract

The invention relates to a broad-band multi-frequency block X-DAB transceiver system for interference-free transmission of high data speed value-added services to mobile receivers in an analog TV channel. The system provides considerable flexibility with regard to error control profiles and therefore data rates, and enables unbalanced error control profiles and hierarchic transmission to be carried out. The invention discloses a method for transmitting high-speed added-value services to mobile subscribers according to the X-DAB system (Extended Digital Broadcasting System) based on several, mainly four, simultaneously broadcast adjacent X-DAB frequency blocks in a common wave network in which relevant service content corresponding to source coded digital input data flow is multiplexed.

(57) Zusammenfassung

Die Erfindung betrifft ein Breitband-Mehrfrequenzblock-X-DAB-Sende/Empfangssystem zur störungsfreien Übertragung von Mehrwertdiensten mit hoher Datenrate zu mobilen Empfängern innerhalb eines analogen Fernsehkanals. Das Systemkonzept bietet eine hohe Flexibilität hinsichtlich Fehlerschutzprofile und damit Datenraten und erlaubt die Realisierung ungleichgewichtiger Fehlerschutzprofile ebenso wie eine hierarchische Übertragung. Verfahren zum Senden von hochratigen Mehrwertdiensten zu mobilen Teilnehmern nach X-DAB-System (Extended Digital Broadcasting System) auf Grundlage von mehreren, vor allem vier gleichzeitig ausgestrahlten, nebeneinander liegenden X-DAB-Frequenzblöcken in einem Gleichwellennetz, auf die ein dem jeweiligen Dienstinhalt entsprechend quellencodierter digitaler Eingangsdatenstrom gemultiplext wird.



FILE, ~~PIN-IN~~ THIS AMENDED
TEXT TRANSLATION**System for the transmission of high-rate value-added services by
terrestrial broadcasting**

The invention relates to a method for the transmission of high-rate value-added services according as defined generically by Claim 1 and Claim 2.

In other words, the invention concerns the field of digital radio of the future: "Digital Audio Broadcasting" (DAB), the standardization of which took place in February 1995 by the European Telecommunication Standards Institute. DAB is suitable for the transmission of high-grade audio programs to mobile, portable and fixed receivers, the real objective being mobile reception. One of the special features of DAB is its ability to transmit additional data at usually relatively low data rates, such as program-accompanying information, traffic information and similar. A plurality of audio programs and/or data services are combined in a so-called DAB ensemble and are broadcast jointly by means of the COFDM (Coded Orthogonal Frequency Division Multiplexing) multi-carrier transmission process in a frequency block of a width of approximately 1.5 MHz

Recently, program providers have shown great interest in using DAB also to transmit value-added services, such as video programs at a higher data rate. In the maximum case, this data rate may occupy the capacity of the entire DAB ensemble. One of the
5 problems in this regard is that of error protection, which, at the (in the DAB system) maximum usable net data rate of 1.728 Mbit/s, is so weak that the system is not totally suitable for mobile reception. With acceptable error protection, therefore, noise-free transmission is possible only in the range of data
10 rates up to approx. 1.2 Mbit/s.

With regard to the DAB system, the X-DAB system (Extended DAB) represents a downward compatible higher-grade alternative to the DAB system, the X-DAB system retaining the physical parameters of
15 the therein used OFDM multi-carrier transmission process as well as the basic structure of a transmission frame according to the DAB system. For specific X-DAB data channels it is possible, in comparison with the DAB system, to obtain better noise immunity together with a higher data rate through the use of coded
20 modulation (multi-stage codes in conjunction with higher phase modulation of, for example, 8-PSK). Through implementation of the X-DAB system, it is possible, for each DAB frequency block, to transmit at all times a net data rate of 1.728 Mbit/s without restriction to mobile users. It is even possible to achieve a
25 maximum rate of over 2 Mbit/s, but with an increase in the

required signal-to-noise ratio at the receiver end in comparison with the lower data rate.

5 If the aim is to transmit high-grade value-added services, such as video programs in PAL quality, to mobile users, then the data rates achievable with the DAB and X-DAB systems are still too low. At present, a standard on the terrestrial broadcasting of digital television (DVB-T) is soon to be published by the responsible authority, the ETSI. To be sure, the DVB-T system 10 makes it possible to transmit high data rates - namely up to a maximum of around 30 Mbit/s per television channel of a bandwidth of 7 MHz in the VHF range or 8 MHz in the UHF range; however, the system concept, which is likewise based on the COFDM method, is aimed primarily at supplying stationary and portable receivers. 15 That is, mobile reception is possible only to a very limited extent even if use is made of a non-standardized extension of the DVB-T system with regard to the type of modulation (see also DE 43 19 217 C2). In order just to come close to the range of the receiver-end signal-to-noise ratio available with the DAB system, 20 it is possible with the DVB-T system to employ no more than four-phase modulation on the subcarriers, as is used also in the DAB system. That is, the maximum transmissible data rate per television channel is in this case still approximately 6 Mbit/s.

25 In conjunction with the DAB system, DE-43 06 590 A1 proposes that four adjacent frequency blocks be broadcast simultaneously in one

television channel, the correspondingly source-coded data stream (such as MPEG-2 for video and audio) being multiplexed onto said frequency blocks, whereby, with a broadband DAB receiver composed of four receivers arranged in parallel with a final output
5 combiner, it is possible to evaluate a net data rate of at most $4 \times 1.728 = 6.9$ Mbit/s. If using error protection adapted to mobile conditions, this net data rate will still be around 4.6 Mbit/s. There is, however, a need further to increase this data rate in order to optimize the transmission quality.

10 The object of the present invention is to provide a method for the transmission of high-rate, added-value services that reliably ensures transmission at even higher data rates than hitherto by using the DAB system.

15 The object of the present invention with regard to the transmission method is achieved by the features of Claim 1.

In other words, therefore, the present invention relates to the
20 transmission of video programs, particularly to mobile users, with at least two simultaneously broadcast, adjacent X-DAB frequency blocks in a single-frequency network, onto which is multiplexed a source-coded digital input stream. The present invention proposes that a free carrier frequency be inserted
25 between the X-DAB frequency blocks. This makes it possible to dispense with a protection interval of 0.2 MHz or greater between

two frequency blocks. This reduces the wide-band requirement for the X-DAB frequency blocks, so that it is advantageously possible to transmit a higher number of adjacent X-DAB frequency blocks within the given bandwidth within a channel of a given bandwidth; this makes a higher transmission rate possible.

A secondary solution to the problem is set out in Claim 2. In order to increase the transmission rate, the present invention proposes that the input data stream be separated into a plurality of individual data streams, these data streams being of varying importance or significance for the quality of the service; and that the individual data streams be distributed amongst the individual X-DAB frequency blocks according to their importance or significance. Using this transmission of a data stream, which is also referred to as hierarchical transmission, it is also possible to enhance error protection for more important data sub-streams or individual data streams and reduce it with respect to less critical ones, in return transmitting the less important ones at a higher rate. The overall data rate is increase thereby.

In an advantageous embodiment, in the transmission method according to the invention, the output signals of the four X-DAB narrow-band transmitters, which provide the four X-DAB frequency blocks, are combined into one common output signal and are thereupon transmitted, for which purpose a summing circuit is

provided, the output of which is connected to an HF stage. At the input end in the transmission process, the input data stream is split between the four X-DAB transmitters by means of a service splitting circuit.

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As an alternative to the summing of the output signals from the plurality of X-DAB transmitters, it is advantageously provided - in order to prevent disturbances of the condition of orthogonality between the subcarriers of the adjacent frequency blocks - that the signals corresponding to the plurality of X-DAB transmitters are combined at the level of digital baseband signal processing after differential modulation of the subcarriers of individual blocks, even before actual OFDM signal generation. Advantageously, the OFDM signals are generated by Inverse Fast Fourier Transformation (IFFT), followed by D/A conversion and I/Q modulation.

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The bundling according to the invention of a plurality of, for example four, X-DAB frequency blocks to provide a broadband X-DAB, BX-DAB system within a normal television channel permits the noise-free transmission of value-added services at a high data rate, in particular to mobile receivers, at a typical data rate of 6.9 Mbit/s.

The system concept according to the invention offers a high degree of flexibility with regard to different error protection

profiles and thus data rates, said profiles being switchable - in the transmission of a data frame - within a frequency block and also between the blocks with regard to the individual data streams of the source signal. In contrast to the above-described DVB-T system, this makes it possible to implement both equal-ratio and also non-equal-ratio error protection. The system concept as claimed is also suitable for a kind of hierarchical transmission, the difference lying - in contrast to the DVB-T system - not in the type of modulation onto the individual OFDM subcarriers, but in the number of frequency blocks to be evaluated.

Hereinbelow, the invention is described in greater detail on the basis of an example embodiment with reference to the drawings, in which:

Figure 1 shows the structure of the transmission frame for the X-DAB system for each frequency block;

Figure 2 shows a block diagram of a narrow-band X-DAB transmitter;

Figure 3 shows a block diagram of a narrow-band X-DAB receiver;

Figure 4 shows the distribution of the X-DAB frequency blocks within an analogue television channel as part of the production of a transmission signal according to the transmission method according to the invention;

Figure 5 shows a block diagram of a broadband X-DAB transmitter according to the invention;

Figure 6 shows a block diagram of a broadband X-DAB transmitter according to the invention;

5 Figure 7 shows a block diagram of a broadband X-DAB receiver according to the invention;

Figure 8 shows a block diagram of a broadband X-DAB receiver according to the invention.

10 As already mentioned in the introduction, there is a need for new system concepts in order to be able to provide value-added services at higher data rates also for mobile receivers without any appreciable loss of quality. Through recourse to already existing systems such as DAB or, as in the case according to the
15 invention, to X-DAB as the basic structure, it is possible significantly to reduce the costs of development in respect of the transmitter- and receiver-related hardware.

For example, for the DAB system there are four different
20 parameter sets (transmission modes) which describe the physical parameters of the transmission frame and of the OFDM process. These parameter sets are identical for the X-DAB system. In so-called transmission mode II for example, a frame corresponds to a duration of 24 ms and contains $L = 76$ OFDM symbols, of which
25 the first is occupied by the synchronization signal and the next $I = 3$ by the fast information channel (FIC), as shown in Figure

1. The remaining symbols, which form the main service channel (MSC), are available for the transmission of useful data. A block in the transmission frame corresponds to the data contents which can be transmitted within an OFDM symbol. Each service occupies its own area in the MSC, the so-called subchannel. The MSC also includes the XSC (X-DAB Service Channel), which, in extreme cases, may take up the entire MSC capacity. Such an extreme case, however, occurs only if a service is to be transmitted at a high data rate, i.e. in this case, the MSC or XSC contains only one single subchannel. The number K of subcarriers used in the OFDM process is likewise different for the individual transmission modes and ranges from $K = 192$ for mode III to $K = 1536$ for mode I. Figure 2 and 3 show corresponding block diagrams of an X-DAB transmitter and receiver, respectively.

In conformance with the proposed solution according to the invention, a plurality of (in the present case up to four) narrow-band X-DAB frequency blocks, which are simultaneously broadcast by all transmitters of a single-frequency network, are accommodated in a television channel with a bandwidth of 7 or 8 MHz (VHF or UHF range), as shown in Fig, 4. The thereby maximum achievable data rate per channel by bundling the capacity of the individual frequency blocks, i.e. the ensemble contents, is, in the case of four frequency blocks, approximately 8.3 Mbit/s. If use is made of error protection adapted to mobile reception, 6.9 Mbit/s are left for the transmission of useful data. That is, per

data channel, approximately 4 MPEG-2 coded video programs in VHS quality including stereo sound or one to two programs in PAL quality can be transmitted and received by mobile users.

5 In addition, the capacity of the four fast information channels (FIC) is available for the transmission of additional data (Fast Information Data Channel, FIDC) each with around 32 kbit/s (mode III: 43 kbit/s).

10 It is advantageous if the frequency blocks are arranged in such a manner that the individual subcarriers of all the blocks are in the same frequency grid Δf . The frequency grid Δf is defined by the useful interval time T_u of an OFDM symbol: $\Delta f = 1/T_u$. The smallest carrier interval is in mode I: $\Delta f = 1$ kHz, and the
15 largest in mode III: $\Delta f = 8$ kHz.

A greater protection interval of 0.2 MHz, as is required in the normal allocation of frequencies for the DAB system in order to prevent neighboring-channel interference between the individual
20 frequency blocks, can advantageously be dispensed with. Merely one single, unassigned carrier frequency is preferably additionally inserted between the frequency blocks. Taking account of the fact that the carrier on the respective block center-frequency is also not assigned, the bandwidth requirement
25 for the four frequency blocks results as:

$$K' * \Delta f = (4 * (K + 1) + 3) * \Delta f = (4 * K + 7) * \Delta f$$

If use is made of the known DAB or X-DAB parameters, a value of approximately 6.2 MHz results for all modes. This system concept is referred to in the following as BX-DAB (Broadband X-DAB).

Basically, after corresponding service splitting of the input data stream, which may possibly originate from a plurality of sources, the desired broadband transmission signal can be generated by the multiple, at present four-fold, parallel connection of known X-DAB transmitters according to Figure 2 and subsequent addition of the output signals of said transmitters. This situation is presented in Figure 5. A separate controller monitors the service splitting and generates the necessary multiplex information (MCI) for the FIC. Owing to inaccuracies of the respective transmission oscillators with the transmission mid-frequencies f_A , f_B , f_C and f_D however, the transmission signal may in this case already contain disturbances of the condition of orthogonality between the subcarriers of the adjacent frequency blocks, which, owing to the absence of a protection interval, may ultimately result in inter-carrier interference (ICI) and thus in a deterioration of the transmission quality.

Figure 6 shows an embodiment of the transmitter according to the invention. This transmitter does not have the aforementioned disadvantages. Consequently, the signals are combined at the

level of digital baseband signal processing (DSP/BB X-DAB SA - SD) after differential modulation of the subcarriers of the individual blocks and still before actual OFDM signal generation. OFDM signal generation can be implemented by means of a module
5 for Inverse Fast Fourier Transformation (IFFT), followed by a D/A converter and then an I/Q modulator. It is of advantage in this regard that, whereas, in the first embodiment of the transmitter according to the invention for the individual frequency blocks, it is necessary, in order to generate a timing signal belonging
10 to an OFDM symbol, to use an IFFT of size $N > K + 1$ with N being a square number ($N = 256$ for mode III to $N = 2048$ for mode I), in the embodiment shown in Figure 6 only one single IFFT of size $N' > K'$ is required ($N' = 1024$ for mode III to $N' = 8192$ for mode I). Each X-DAB block is allocated a fixed assignment - dependent on
15 the selected mode of the IFFT input vector on which the corresponding differentially modulated PSK symbols are stored. Following the IFFT, all that is then required in the transmitter is one single D/A conversion (one module each for the I- and Q-channels) as well as one single I/Q modulator. Owing to the
20 greater IFFT bandwidth, however, the D/A conversion must take place at four times the timing rate, i.e. the duration of the sampling interval after the IFFT is only around $0.122 \mu\text{s}$ instead of $0.488 \mu\text{s}$ in the first embodiment of the transmitter. The frequency f_{so} is used as the transmission mid-frequency, as shown
25 in Figure 4.

Broadband X-DAB receivers according to the present invention are now described with reference to Figure 7 and Figure 8.

In order to be able to evaluate the entire data stream in the broadband transmission signal at the receiving end of the transmitting/receiving system according to the invention, two principles are possible, as shown in Figure 7 and 8. First, if there are four narrow-band X-DAB transmitters at the transmitter end, it is possible to employ four parallel-connected narrow-band X-DAB receivers which are tuned to the respective frequency-block mid-frequencies f_A to f_D and which thus evaluate the ensemble contents of the corresponding block (see Figure 7). Owing to the fact that the frequency blocks are directly adjacent to each other, if narrow-band receivers are used there is inter-carrier interference (ICI) because the subcarriers belonging to the neighboring blocks are included in the FFT module of the OFDM demodulator. This, however, has virtually no adverse effect on the transmission quality, since, in the previously discussed transmitter implementation (see Figure 6), all the carriers are in the same frequency grid, with the result that the condition of orthogonality is not violated. Furthermore, the negative consequences of the Doppler effect for mobile reception are only minimally amplified thereby. The four receiver output data streams are again combined in the service combiner to form one or more overall data streams. The control of the just-described broadband receiver with regard to the data streams is effected in

the combining controller on the basis of the evaluation of the information transmitted in the FICs, similarly to the DAB or X-DAB concept.

5 Figure 8 shows an alternative to the above-described receiver similar to the transmitter shown in Figure 6. Instead of using four narrow-band receivers directly in parallel, it is thus possible for the signal to be recovered using just one single OFDM demodulator. Such a broadband receiver can be implemented by
10 an I/Q demodulator tuned to the frequency f_{so} , an A/D converter for each of the I- and Q-branches, as well as a following FFT of size N' . After corresponding allocation, the values of the FIT output vector can again be allocated to the digital baseband signal processing of four parallel X-DAB receivers (DSP/BB X-DAB
15 EA - ED), the output data streams of which are subsequently combined to form an overall data stream, as described above.

This second embodiment of the receiver according to the invention is superior to the first embodiment thereof when it is a matter
20 of evaluating the entire data stream. With the above described broadband X-DAB transmitter/receiver concept according to the invention, however, it is also possible to accomplish the so-called hierarchical transmission of a data stream. This requires that the source data stream can be separated into a
25 plurality of individual streams, these having different significance or importance with regard to the quality of the

associated service, for example with regard to picture quality. Thus, it is possible, for example, to increase the error protection for more important data streams and to reduce it for less important ones while, in return, transmitting at a higher data rate. Changes in error protection even within a transmission frame are easy to implement with the X-DAB system, but are not possible with the initially described DVB-T system. If, at the transmitter end, the data streams are distributed among the individual frequency blocks according to their importance, beginning, for example, with the lowest frequency, then reception quality and receiver costs can be exchanged for each other, a technically simple receiver, for example, evaluating just one frequency block, for example block 1, which is tuned to the mid-frequency f_A . In this case, the receiver is identical with the normal X-DAB narrow-band receiver with the maximum FFT size $N' = N = 2048$. In order to improve the service quality, it is necessary for a further block to be added and be co-evaluated, for example block 2, tuned to the mid-frequency f_{S1} . Since an FFT of the maximum size $N' = 4096$ is required, the receiver must be correspondingly broadbanded. In the case of video transmission, this may signify, for example, a quality step from VHS to PAL. In this scheme, frequency blocks 3 and 4 may likewise be assigned to a separate service and be evaluated independently of frequency blocks 1 and 2, the receiver being tuned to the mid-frequency f_{S2} .

With regard to the above-described frequency blocks, it is also possible for an additional substream to be transmitted to frequency block 1 or 2, this contributing toward a further improvement in the quality of the service. In order, in this case, for example, to achieve full picture quality, it is necessary to use the most complex and thus most costly receiver, with the maximum FFT size $N' = 8192$ with four-fold parallelization of the X-DAB baseband signal processing. The arrangement of an unassigned carrier between the individual frequency blocks has, in all receiver types irrespective of FFT size and correspondingly selected mid-frequency, the consequence that the input signal is always without a direct component, this guaranteeing optimal modulation of the A/D converters.

New Patent Claims 1 to 5

1. Method for the transmission of high-rate, value-added services to mobile users according to the X-DAB system (Extended Digital Broadcasting System), with at least two simultaneously broadcast, adjacent X-DAB frequency blocks in a single-frequency network, a digital input data stream, source-coded according to the particular service contents being multiplexed onto said frequency blocks, characterized in that a free carrier frequency is inserted between the X-DAB frequency blocks.
2. Method for the transmission of high-rate, value-added services to mobile users according to the X-DAB system (Extended Digital Broadcasting System), with at least two simultaneously broadcast, adjacent X-DAB frequency blocks in a single-frequency network, a digital input data stream, source-coded according to the particular service contents being multiplexed onto said frequency blocks, characterized in that the input data stream is separated into a plurality of individual data streams, these data streams having different significance or importance with regard to the quality of the service; and in that the data streams are distributed among the individual frequency blocks according to their significance or importance.

3. Method for transmission as defined in Claim 1 or Claim 2, characterized in that the signals corresponding to the plurality of X-DAB frequency blocks are transmitted combined into one common output signal.
4. Method for transmission as defined in Claim 1, Claim 2, or Claim 3, characterized in that signals corresponding to the plurality of X-DAB frequency blocks are combined at the level of digital baseband signal processing (DSP/BB X-DAB SA-SD) after differential modulation of the subcarriers of individual blocks, even before actual OFDM signal generation.
5. Method for transmission as defined in Claim 4, characterized in that the OFDM signals are generated by Inverse Fast Fourier Transformation (IFFT), followed by D/A conversion and I/Q modulation.

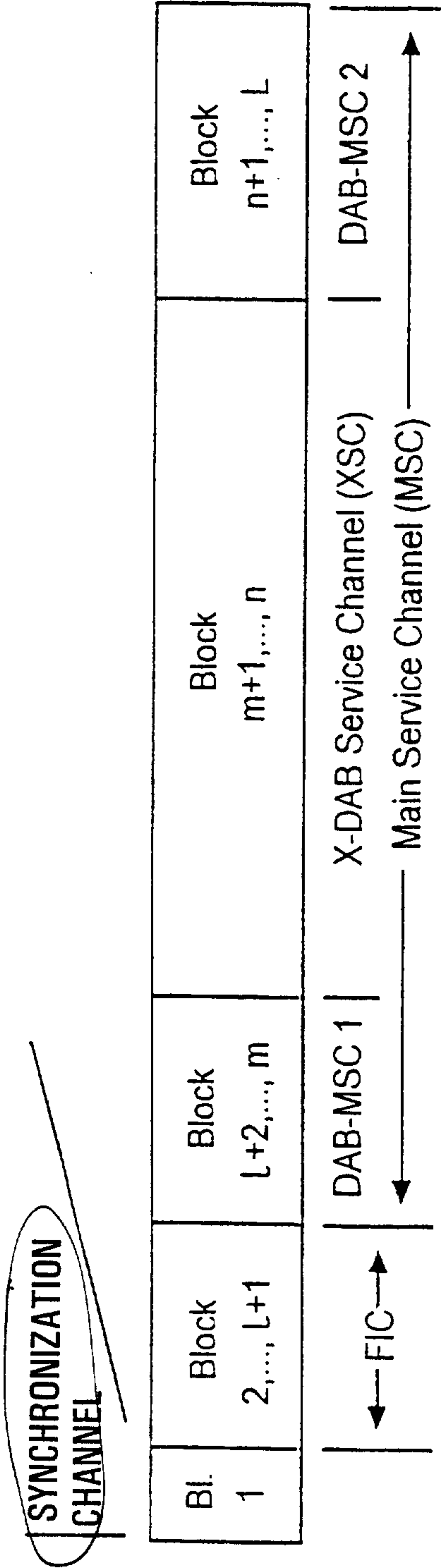
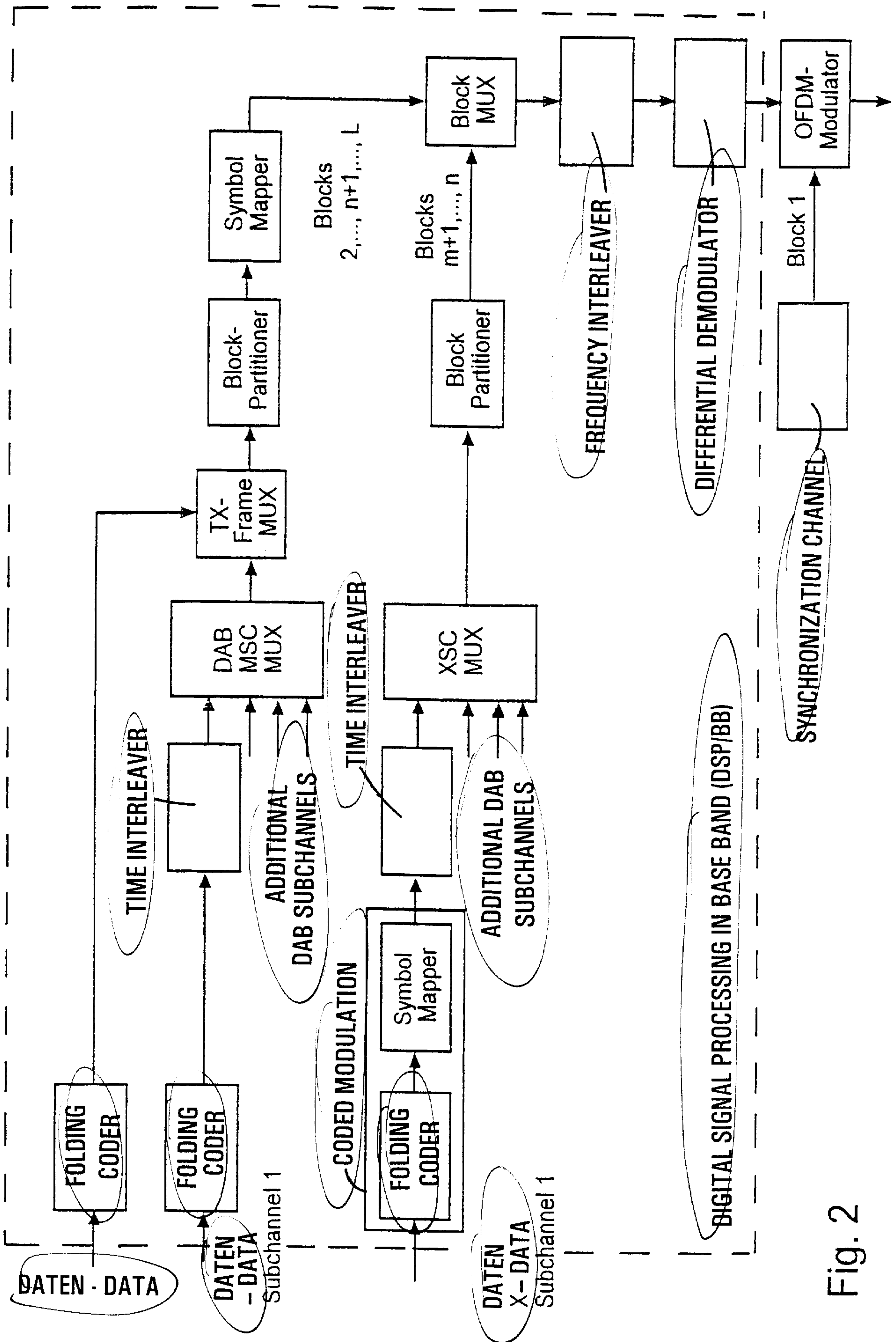


Fig. 1



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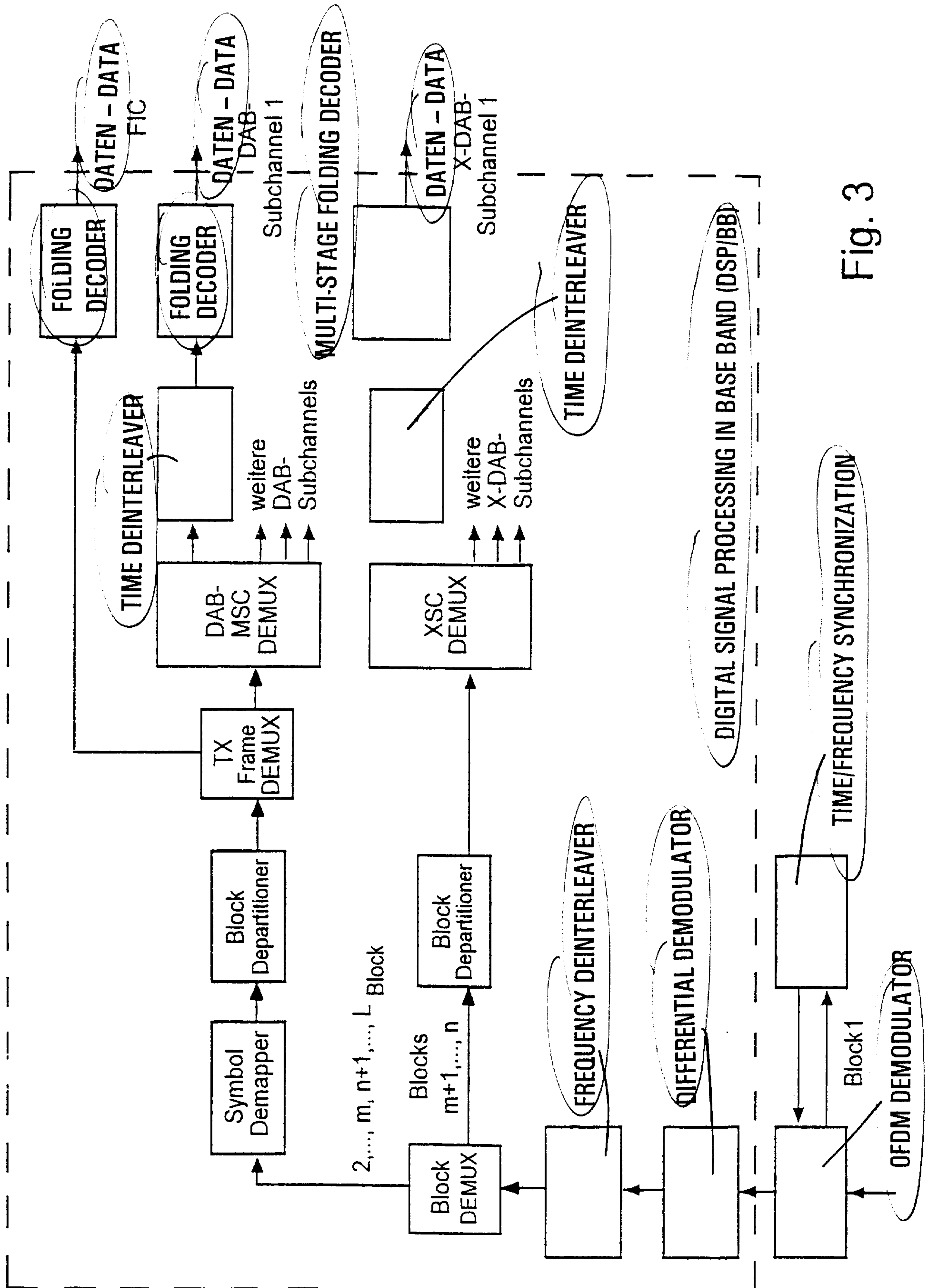


Fig. 3

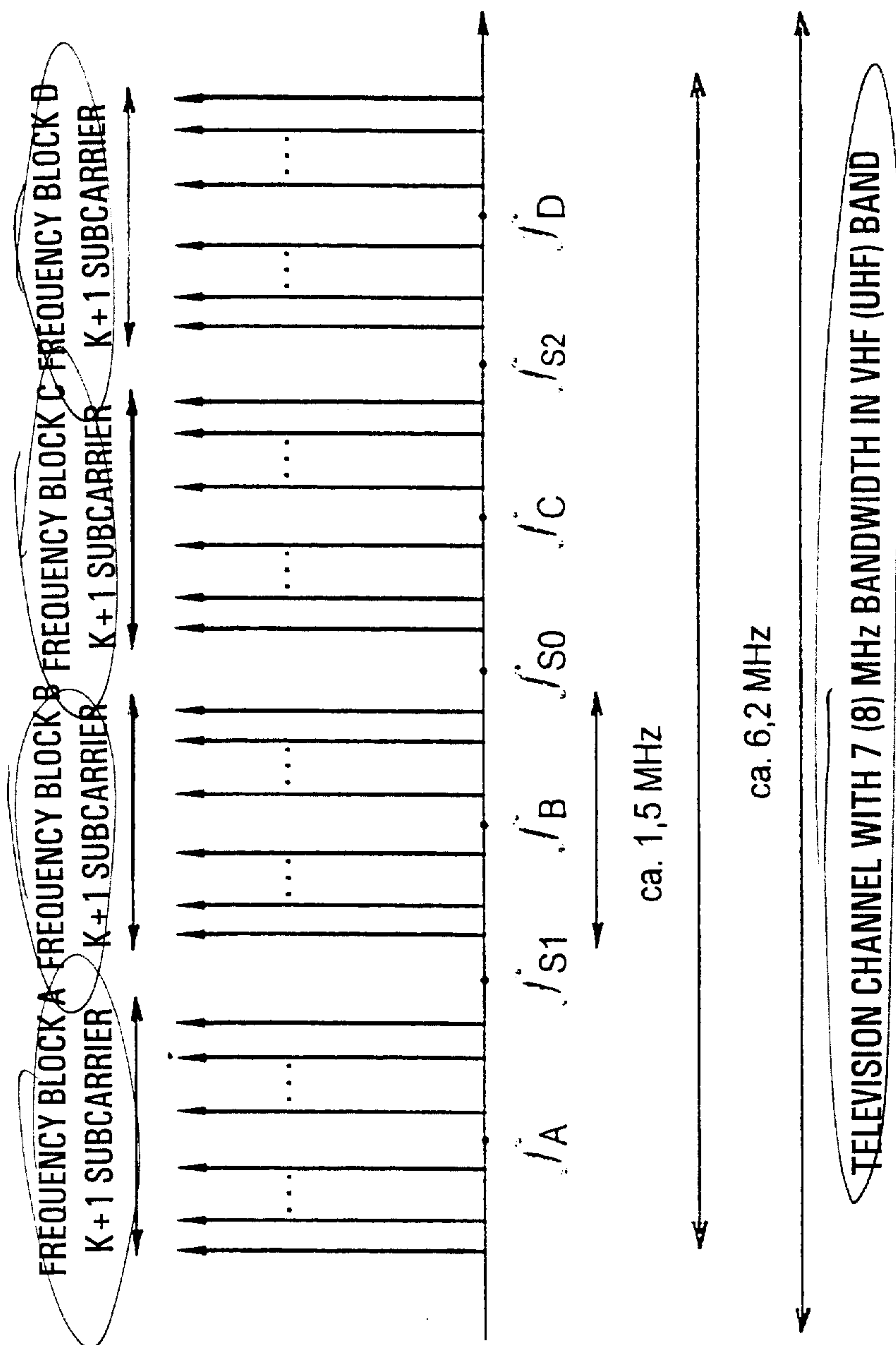


Fig. 4

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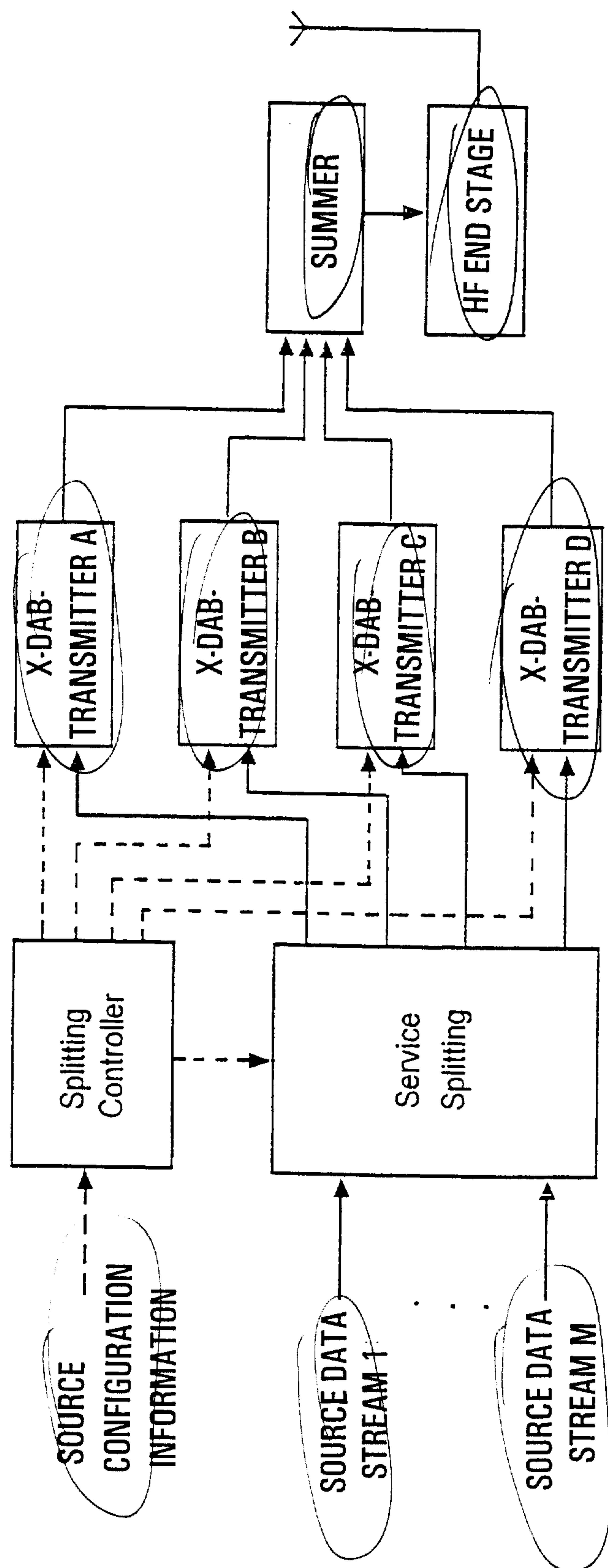


Fig. 5

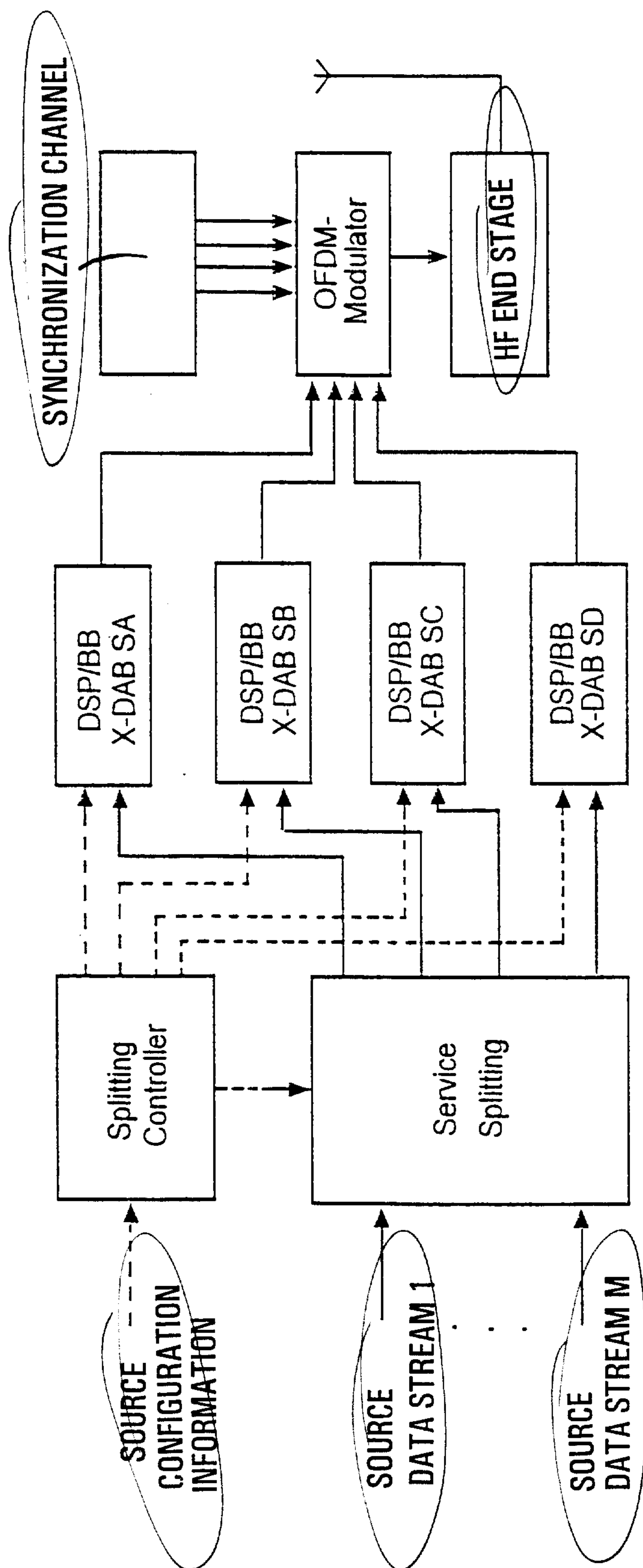


Fig. 6

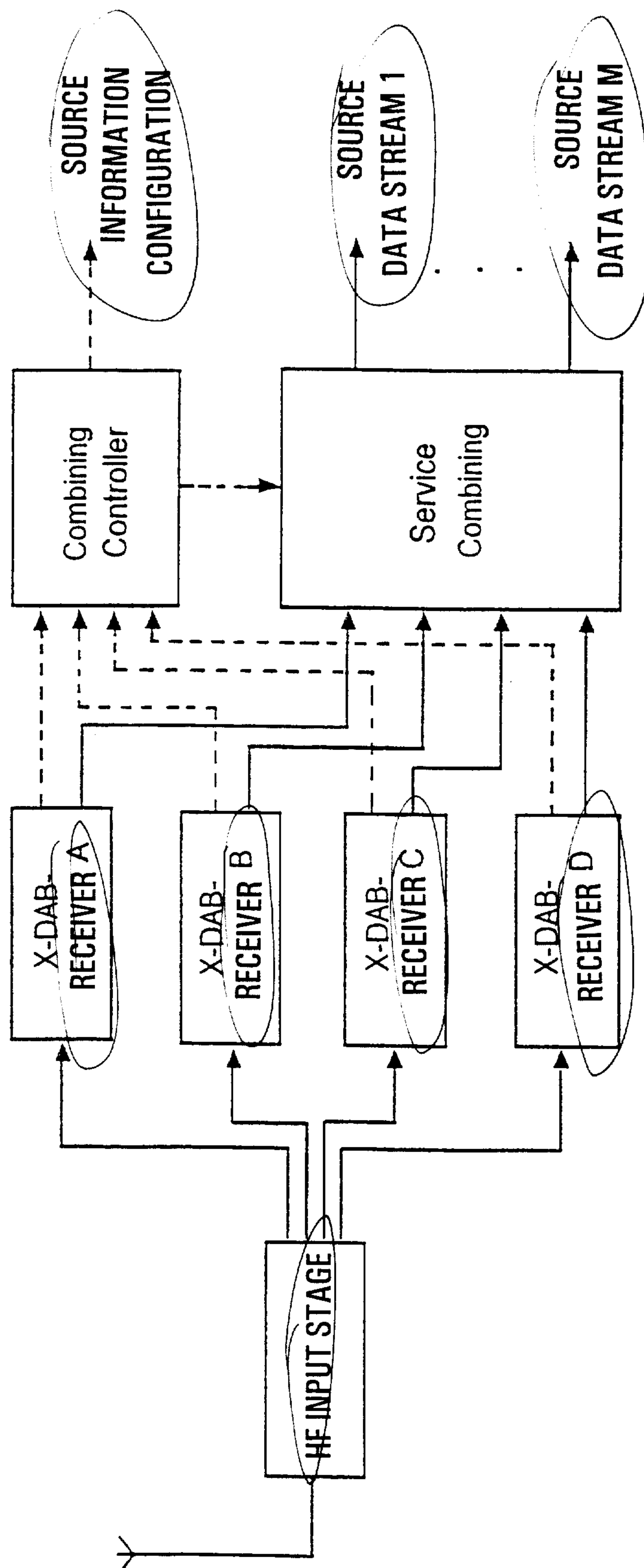


Fig. 7

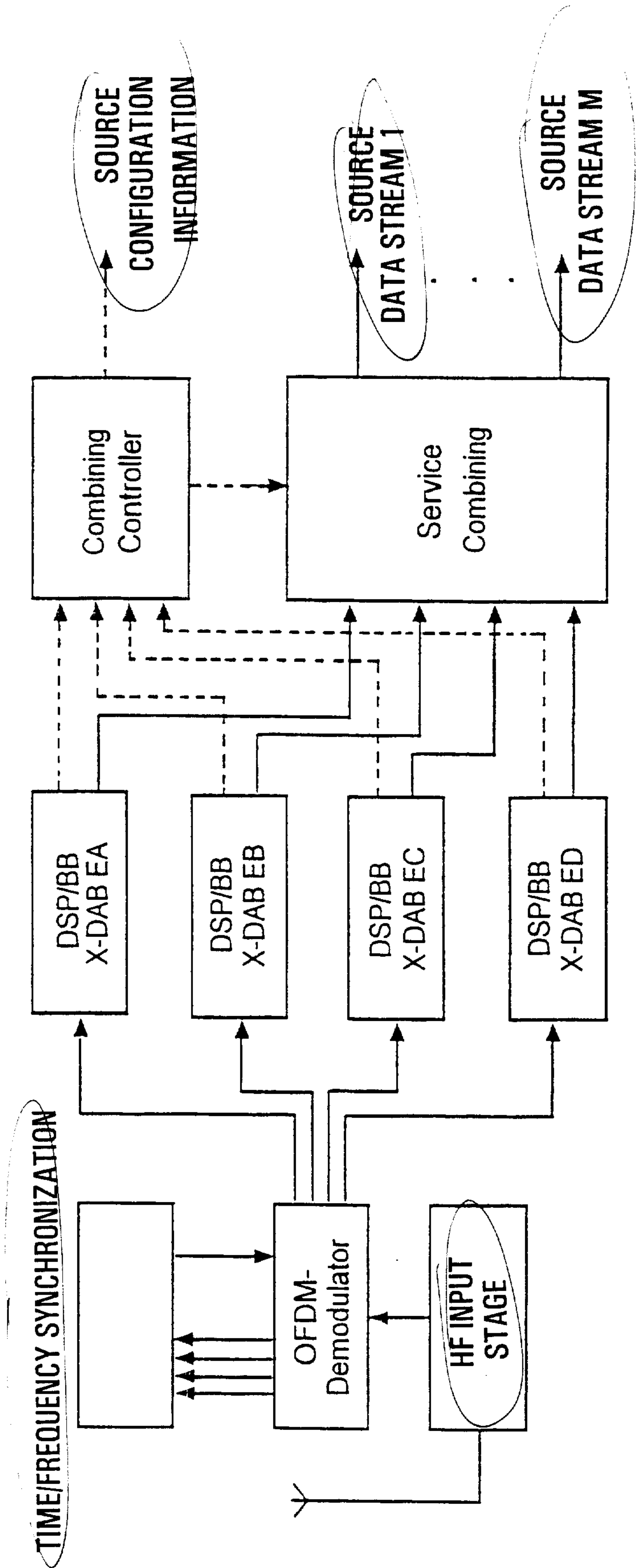


Fig. 8